

Block Pattern adaptation for Greek female
adolescents with Scoliosis of the Spine:
An investigation into the feasibility of
incorporating body shape asymmetry into
Sizing Systems to improve garment fit

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*'Block Pattern adaptation for Greek female adolescents with Scoliosis of the Spine:
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Abstract

Scoliosis of the spine is defined as a side-to-side deviation from the normal frontal axis of the body resulting in body asymmetry, and as a complex, three-dimensional and multifaceted deformity, not only affects a female adolescent's appearance - fit, usability and appearance of clothing - but can also compromise her health and ability to function. Scoliosis affects at least 2.9% of the population in Greece, appearing particularly among children aged 8-14 years, and more frequently in girls (9 girls for 1 boy).

This study traces previous initiatives and current provision for clothing people with divergent body figures, exploring issues at the intersection of human anatomy and fashion, while it takes place in Greece, starting with measuring procedures specifically adapted for body asymmetry that comply with the appropriate code of *ethics*.

External body measurements provide non-invasive evaluation of changes in external asymmetry due to scoliosis, while analysis of the measurements related to the trunk can document the asymmetry arising from the different types and degrees of spinal curvature, providing a 3D classification of scoliotic deformities. Both right and left body halves of 75 females aged 16-22 years of age, diagnosed with Adolescent Idiopathic Scoliosis (AIS), are measured in order to register their different body shapes and to classify them in different scoliotic groups, according to the magnitude and type of their scoliosis. The asymmetric basic pattern blocks derived from the *median* body measurements for each scoliotic group will be more tolerant of bodies with scoliosis, providing a better garment fit than conventional symmetrical patterns. These new 'blocks'

will have the potential to be used in mass production, after the development of sizing systems based on body asymmetry, whereby an 'aesthetic' and an 'ethical' dimension in design could be then incorporated. Applying auto-ethnography, as well as using participant observation and interviewing methods, this research will help gain a deeper understanding of the culture and the needs of the specific target group.

Future challenges relate to design perspectives of fashionable clothing for females with non-standard body dimensions, with particular emphasis on scoliosis, having potential for wider application in *mass customised* apparel for scoliosis.

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Glossary

AIS: Adolescent Idiopathic Scoliosis

Anthropometric data: dimensional measurements of human body parts, which are key to any garment sizing system (Pechoux & Ghosh, 2002:11).

ATR: Axial Trunk Rotation

Basic pattern or block is a two-dimensional (2D) representation of the body measurements with a minimal addition of length and width called '*wearer ease allowance*' to allow for body movements, expansion and comfort (Rosen, 2004).

Body shape: the cumulative product of a human's skeletal structure (build) and the quantity and distribution of muscle and fat on the body (Rasband & Liechty, 2006:19)

Body image: the mental picture an individual has of their body at any given moment in time (Kaiser, 1998:98).

Design ease is the amount of fabric needed to make the design or style of the garment (Chen, 2007:132). *Design ease* is used to create a desired look of the garment, such as determining whether the garment will be loose-fitting, semi-fitting or close-fitting (Branson & Nam, 2007:266)

Fitting or Wearing ease is the amount of extra fabric, which is allowed for body movement and comfort in a garment (Chen, 2007:132). *Wearing ease* allows the wearer to breathe easily, bend over or raise the arms, without stretching the seams. It also allows sitting, walking and achieving other movements with ease, giving a comfortable feeling which determines a good fit in garments (Daanen & Reffeltrath, 2007:203).

Fit preferences: the way individuals prefer garments to lay on their body such as tight, loose or semi-loose fit.

Garment ease or tolerance according to Petrova (2007:61), is defined as the difference between the body measurements of the person wearing a garment and the garment measurements. Garment ease includes, *wearing ease* and *design ease*.

(In this study, garment tolerance relates only to *wearing ease*, as the basic blocks used are **Close-fitting Basic Pattern Blocks**, having no *design ease* at all and only the minimum amount of *wearing ease* required)

Garment fit: the relationship between the size and contours of the garment to that of the body (Chen, 2007:132).

Garment (or clothing) sizing: any series of graduated categories of dimensions whereby manufactured garments are classified (Petrova, 2007:61).

Garment Style: the distinctive lines and characteristics and characteristics of a garment design (Kaiser, 1998:4).

Ideal body shape: the body shape, which is well balanced with no area exaggerated. This is the body shape usually used in patterns and garment designs (Rasband & Liechty, 2006:24).

Ill-fit: garments that do not conform to the body, while they can be too tight, too loose, or show wrinkles, making the wearer feel physically and psychologically insecure (Rasband & Liechty, 2006:3).

Key dimensions: body dimensions with strong relationship with other body dimensions, such as bust, hip waist and sometimes height (Petrova, 2007:63).

Normal controls: Adolescent girls without scoliosis

Personal values: standards or principles that guide an individual's action and thought, they help define what is important to us by guiding our choices or preferences (Kaiser, 1998:290).

Production pattern: is the pattern created once the prototype '*basic pattern*' of a specific clothing style is designed, with additional manipulation that generates the final pattern (e.g. changing the bust dart, adding seam allowances, etc). The production pattern is, then used for huge production of garments, graded in different sizes.

RTW (ready-to-wear) is mass produced clothing in standard sizes.

Size group: similar body measurements (Petrova, 2007:57).

Sizing system: a set of sizes comprised using similar theory and methodology (Petrova, 2007:57)

Sewing or seam allowance refers to the area between the stitching line and the raw, cut edge of the fabric. Sewing accurate seam allowances is an important key to having pattern pieces fit together.

Three-Dimension (3D) Body Scanning: the use of a light source (laser, white light or other type) to capture the image of the body in the three dimensions of x, y, z (width, height, depth) ([TC]², 2012).

Well fitting: a garment that conforms to the human body and has adequate ease of movement, has no wrinkles and has been cut and manipulated in such a way that it appears to be part of the wearer.

(In this study, garment assessment was based upon my own visual evaluations, taking into account the subjects' personal comments on the toiles' fit, after the wearer trials)

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Appendix D1 consists of the *Participant Evaluation Sheet*, the *Participant Evaluation Form* and the *Participant Consent Form*, as they were presented to the participants, in order to fill in, for obtaining feedback for the wearer trial.

Appendix D is the participant evaluation forms (Q&A), discussed in Chapter 10, filled in by 14 subjects, chosen randomly, by lottery, from the 75 participants.

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Chapter 1

Introduction: A personal perspective as background to the research

«There is no excellent beauty that hath not some strangeness in the proportion...» ['Of Beauty', Francis Bacon (1561-1626)]

It is my personal opinion that perception of beauty, to date, has been shaped by images of human bodies in western art: artists of different eras and cultures attempted to build or paint the perfect human form, in various ways. Perfect human bodies were encapsulated in marble, stone and paint, while even images of the Crucifixion depicted a beautifully proportioned body of Christ. Nevertheless, while there were various interpretations of beauty - for example, large fleshy women were revered in the late nineteenth century - the '*canon*' of western art did not include images of disabled or disfigured people. Disability did not fit within the classical standard of beauty (Carr-Harris, 2009).

What I would like to convey in this thesis, however, is that our interpretations of beauty can be challenged every day:

Ever since I had been affected by polio, at the age of 3 months, in 1972, my orthopaedist feared the later development of scoliosis of the spine. Having in mind that in post-polio survivors, as myself, the incidence of scoliosis is estimated at approximately 30%, I was not surprised when I was, actually, diagnosed with scoliosis at the age of 14 years, in 1986. Until then, my spinal deformity had been part of who I am, making it really hard for me, as years went by, to fit into some of the garment styles I liked, due to my body's

asymmetry between the right and left side. Nevertheless, despite the fact that most of the times I could not fit in symmetrical conventional retail clothing, I had always tried to enhance my individuality through my outward appearance, which was depicted in the way I dressed.

At the age of fifteen, a spinal cord surgery, due to scoliosis, confined me in a wheelchair for six months. At that time, I began to feel helpless due to loss of function, while my forearm crutches or wheelchair symbolized a lack of ability - or *disability*.

Physiotherapists worked with me to help me *overcome* my disability, to enable me to *fit in* with my able-bodied peers. In the rehabilitation hospital, I met another patient - a young man in a wheelchair - who felt that women in wheelchairs were unattractive. Strangers passing me by, in the streets of Thessaloniki, my hometown in Greece, would say: "what a shame... she's so beautiful..."

These attitudes of physiotherapists, strangers and even disabled peers, confused me. Why was it necessary to overcome my disability? Why aren't disabled women considered attractive? And why is it so shocking to see a young woman in a wheelchair?

I came to realize that people were challenged by the image of a beautiful woman in a wheelchair because it upset their concept of physical beauty.

On the contrary, Aimee Mullins, former paralympian and model with two prosthetic limbs (Figure 1.1), believes that a prosthetic limb doesn't represent the need to replace loss, however, it can stand as a symbol that the wearer has the power to create whatever it is they want to create in that space. Therefore, people that society once considered disabled, can now become the architects of their own identities and indeed continue to change those identities by designing their bodies from a place of empowerment¹. If one

¹ <http://robots.net/article/2800.html> (Accessed 3rd October 2009)

individual's own attitudes evolve overtime, populations of people with disabilities can be as diverse as society in general.



Figure 1.1. Aimee Mullins

Moreover, Laura Ferguson – a New York-based visual artist whose drawings, paintings, and artist's books have been exhibited widely and are part of numerous public and private collections – for the past fifteen years, is known for her '*Visible Skeleton Series*' (Figures 1.2 and 1.3). The body she portrays is softly voluptuous in the style of *Titian* or *Degas*, yet deformed by scoliosis: a flawed but perhaps more interesting kind of beauty (Dreger, 2004). Arresting and beautiful drawings of a woman's body through which the interior skeleton is visible, represent her art and body. Multi-layered works on paper are based on actual medical images of the artist's anatomy, including x-rays and a 3D spiral

CT scan². Her art with its unusual perspective demonstrates to viewers the body's beauty, even the beauty of bodies that have been labelled '*abnormal*'. Her striking figures, in motion or in other positions of daily life, emphasise how natural and human is the body, and encourage greater acceptance and appreciation of the variety and uniqueness of individual bodies.

This kind of art stimulates new ways of thinking about the body and disability, presenting Scoliosis as a flawed model of the beautifully designed human musculoskeletal system that has its own more complex beauty, due to its asymmetry (Dreger, 2004).



Figure 1.2. *Balancing figure with visible skeleton*, 2002

² www.lauraferguson.net (Accessed 1st April 2006)



Figure 1.3. Crouching figure with visible skeleton, 2000

Therefore, disabled people have the power and ability to re-create their bodies in whatever form they choose, and disability can be both whimsical and fashion-able. Mobility aids and prosthetic limbs do not need to symbolize loss. Using cutting-edge technology combined with high fashion such devices can make a person *super-abled* and *fashion-able*.

Grounded in and motivated by my personal experience, this thesis, therefore, sets out to investigate solutions in encouraging people with disabilities to follow Mullins's and Ferguson's lead by creating a new standard that equates *disability* with *beauty*.

1.1. Scoliosis: A Spinal Deformity creating Body Asymmetry

The spine, or vertebral column, is located centrally, at the back of the body, and has many functions – above all, being necessary for providing structure, flexibility, support and movement for our bodies. It acts as an attachment site for the muscles of the back and body core, as well as the posterior ribs, while it encloses and helps to protect the spinal cord (Anderson, 2007: 44-65).

Scoliosis is a medical term taken from a Greek word meaning *curvature*, and was first used by Hippocrates to denote any curvature causing deformity of the spine (Tran, 1997). Today, *scoliosis* can be defined as an abnormal, side-to-side curvature of the spine, which measures greater than 10° in a radiograph, and is usually associated with rotation of individual vertebrae (Stricker, 2002: 13-20). Depending on the curve pattern and the size or magnitude of the curve, scoliosis may be barely seen or it may have significant visible symptoms. Its most obvious symptoms are cosmetic, while the curvature can exist in the lumbar, thoracic, or cervical spine, and often does in two or all three of these areas along the vertebrae, causing spinal deformity. Moreover, pain and cardiopulmonary complications, due to compression of the heart and lungs, are also common (Larson, 2000), while difficulty in sitting or standing, stiffness, and spinal rigidity, are often associated with scoliosis.

One of the most common visible symptoms is shoulder height asymmetry, in which one shoulder appears higher than the other. A shift of the body to the right or the left can occur especially when there is a single curve in the thoracic (chest-part) or the lumbar (lower back) part of the spine without a second curve to help balance the patient. This is often seen as some waistline asymmetry in which one hip appears to be higher than the other and may result in one leg appearing taller than the other. In general, a *prominence*

on the back or a rib *hump* secondary to the rotational aspect of scoliosis is the most visible sign of scoliosis (Figure 1.4).



Figure 1.4. Waistline asymmetry and body shifted to the right

According to the International *Scoliosis Research Society*, approximately 4% of the global population has an abnormal curve in their spine called scoliosis³, a deforming condition, which can cause pain and late disability, if undetected or ignored (Figure 1.5). In every 100 adolescents aged 9-14 worldwide, five to ten are diagnosed with scoliosis of the spine⁴, while one in nine females and a smaller percentage of males have some sign of scoliosis. Scoliosis occurs in all types of people, in all countries and in all shapes. In Greece, scoliosis affects at least 2.9% of the population, appearing particularly among

³ <http://www.scoliosisnutty.com/what-scoliosis.php> (Accessed 17th February 2014)

⁴ American Academy of Orthopedic Surgeons, <http://www.aaos.org/> (Accessed 8th November 2007)

children aged 8-14 years, and more frequently in girls (9 girls for 1 boy) (Grivas *et al.*, 2002:20-24).

On an x-ray, a scoliotic curve has an **S** or a **C** shape (U.S. National Library of Medicine, National Institutes of Health). It can be present at birth, develop during childhood and adolescence, or occur in adulthood as a result of degenerative changes in the spine. Scoliosis and other abnormal spinal curves also can develop as a result of posture or other developmental disorders, or as a direct result of disease. It is a progressive condition that can continue to progress even after skeletal maturity.



Figure 1.5. Left: Clinical photograph of an adolescent girl with right thoracic idiopathic scoliosis, Middle: X-ray clearly demonstrates right thoracic scoliosis, . Right: Her rib prominence is most obvious when bending forward (Courtesy of Texas Scottish Rite Hospital for Children)

1.2. The Importance of Garment Fit in Adolescence

Longitudinal studies of a child's growth point out that there are two major periods of growth and one of maturation. During the second period of growth, the growth rate can achieve 7 to 10mm per month in height, and idiopathic scoliosis worsens most then, particularly among girls, given that, in general, girls mature at about 16 ½ years of age

(Coillard & Rivard, 2001:1140-41). This occurs due to the fact that longitudinal growth is immediately followed by a volumetric increase, particularly in girls whose pelvis expands, chest becomes larger and bones become more massive, while the slim and willowy preadolescent girl becomes a woman.

Unfortunately, certain changes in users' configuration and posture, caused by scoliosis or other deformities of the spine, affect fit, usability and appearance of clothing, due to body asymmetry, while the divergent female body is often discriminated and considered as marginal. It has long been acknowledged that a progressive, deforming condition such as *scoliosis* is likely to have a serious impact both physically and psychologically upon the lives of adolescents, especially female adolescents (Weiss *et al.*, 2008: 9-25). In addition, the ability to perceive one's identity is a variable measured by self-esteem, which marks its most formative beginning in adolescence (Menger, 2003). Self-image is an important issue for adolescent girls and, to a large extent, will be dependent on how others view them, react to them, and respond to them. Having difficulty to fit in symmetrical conventional clothing and appear as their peers can have a negative effect on an adolescent's with scoliosis self esteem. It is a psychological need for them to feel attractive and not be set apart from the group, by the clothes they wear (Hallenbeck, 1966: 34-40). To have the same dress code as their peers is vitally important as it gives a sense of '*belonging*'. Social integration and acceptance are, thus, established for them when they wear, or have adapted garments that conform to their unique body figures. A young girl with scoliosis will seek the opinion of the world surrounding her, from friends, family, peers, authority figures, and in particular from her parents, if she may find that certain styles do not hang right, or fit properly: i.e. a tight top will accentuate a hump on her back. Close-to-the-body fitting apparel can often cause body-dissatisfaction and, therefore, negative body cathexis, while garments, which need to be rearranged

constantly, in order to provide comfort or a better fit, can only add to this dissatisfaction (Watkins, 2006).

1.3. Research Questions

This research project is accomplished in a Greek context and the selected target group consists of 75 females between 16-22 years of age, diagnosed with Adolescent Idiopathic Scoliosis (AIS) of the spine. I selected this particular age group, due to the fact that in their late-puberty, girls' bodies have developed an almost full female figure, while, at the same time, girls of that age are not as mature as older women are, when it comes to selecting clothes for a good fit, and can easily misjudge fashionable, or trendy clothing, that might not fit them properly. Therefore, the study would aim to address questions such as:

- Do adolescent girls with scoliosis have trouble finding clothes that fit their bodies and preferences and, if yes, what are the implications of today's clothing fit for them, as consumers?
- Is there a need for developing a sizing system for adolescent girls based on body asymmetry due to scoliosis?
- Which can be the assessment parameters for female scoliotic body shape identification?
- Would it be possible to find some numerical correlation parameters in order to identify the female scoliotic body shapes by using a few critical body dimensions?
- Is it feasible to produce garments, in a customised level, that are derived from pattern profiles based on median body measurements of adolescent girls with scoliosis, according to groupings, conforming to various types of scoliosis?

Initial data were collected through a 25-question survey on participants' experiences and opinions concerning clothing, fit, brands, impact of media and perception of the body in relation to clothing, which took place in a hospital setting (Appendix A1 – A). In order to investigate the relationship between body shape and clothing, the questionnaire, gathered by each of the 75 participants separately, consisted of a consumer survey supplemented with one-to-one informal interviews during the filling out and a market analysis on apparel fit and branded clothing preferences, providing information on the relation between clothes, brands and the body as the interviewed girls experienced it. The questionnaire included the respondents' social background, information and personal opinions on their body image, experiences with clothing purchases including the search for the correct fit and style, as well as brand and colour preferences. Overall, the survey provided information (Chapter 3: 3.4-3.7: pp.55-98) about adolescent girls' experiences with the fit of clothes and updating in current fashions, such as:

- How do they keep informed and how do they respond to today's fashion trends?
- What is regarded as problematic when it comes to buying clothes?
- How do they adapt their own shopping habits to ready-to-wear (RTW) apparel size and fit?

1.4. Research aim, methodology and objectives

1.4.1. Research Aim

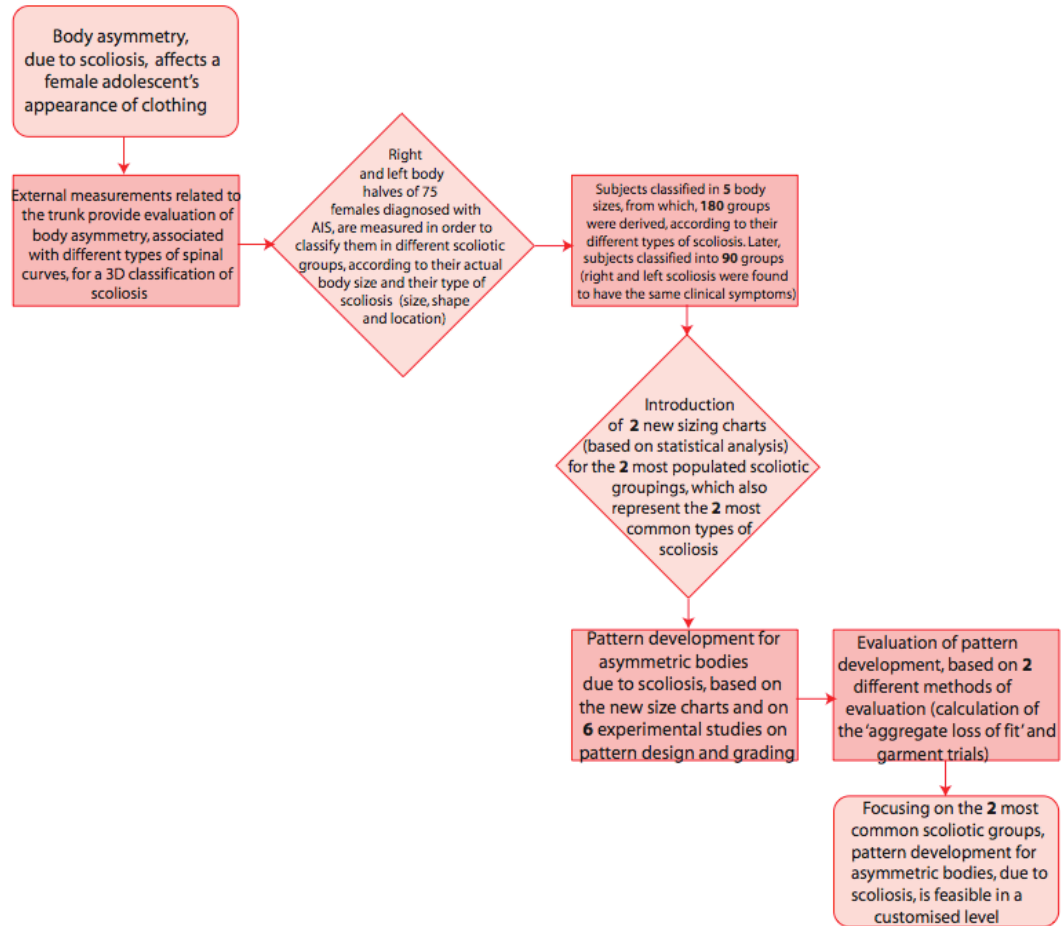
The aim of this study is to classify 75 Greek females between 16-22 years of age, diagnosed with AIS, in new sizing systems that conform to their actual body size, taking into account the size and shape of their spinal deformity due to scoliosis, implementing a new approach to pattern design, with focus on user-oriented pattern design. As Ashdown

and O' Connell (2006) have pointed out, well-designed sizing systems help to provide clothing that fits, since well-fitting clothing is important for women, enhancing their outward appearance (Ashdown & O' Connell, 2006:139).

Therefore, this study is a practice-led research, conducted through a series of experimental developments of new asymmetric pattern blocks, firstly derived from my own measurements, using an auto-ethnographic approach, as a basis. Further experiments were then evaluated through application of certain statistical tools (descriptive statistics, regression analysis, PCA) and wearer trials based on dress toiles constructed on patterns derived from the median measurements of 180 different scoliotic groupings, conforming to the participants' actual body size, as well as the size and shape of their spinal curvature due to scoliosis.

These sets of basic pattern blocks, addressed to girls with various types of AIS, introduce 4 different basic styles (Basic Bodice with One-piece Sleeves, Basic Dress with One-piece Sleeves, Tailored Skirt and Basic Trousers), focusing on body asymmetry due to scoliosis, conforming to the different left and right body halves. The 'blocks' could be later translated in fashionable designs with high aesthetic values, which would be more tolerant of bodies with scoliosis, providing a better garment fit from conventional symmetrical patterns, while having the potential to be used for mass customised apparel, with the development of new sizing systems based on body asymmetry.

1.4.2. Research Design



Within the direction of research questions, methodology entailed a five-phase progress, where both qualitative and quantitative approaches were considered:

- The first phase included the compilation of a questionnaire addressed to females aged 16-22 years diagnosed with AIS, regarding perception of their body image in relation to conventional retail clothing, and the general concepts of identity, body image, self-esteem and the impact of clothing (branded or not) and fashion, in general.

- The second phase involved tracing previous initiatives, current provision and future challenges for clothing females with non-standard body dimensions, focusing on the advantages and limitations of Body Scanning Technology. This resulted in an experimental study on body measuring methods, whereby traditional manual pattern-making practices were compared to measurements extracted from the *[TC]² 3D* body scanner, for the construction of 6 simple-styled toiles.
- During the third phase of the research, a set of body measurements based on body dimensions of the same individuals with distinctive spinal features due to scoliosis that had participated in the survey, was compiled. Body measurements of 75 females aged 16-22, with various types of AIS were taken manually, as accurately as possible, after thorough observation of their different severity curves. The method employed was to measure both right and left body halves of 75 females -- all of them were pre-operative patients, while only 9% of them were scheduled to undergo surgery at some point, in the future -- in order to register the magnitude of the curvature due to scoliosis, causing body asymmetry. The aim was to design basic pattern blocks, having in mind the particular disfigurement caused by scoliosis - which was not specifically covered in a previous study of unique figures in the 'Easytex' project (Hernandez, 2000:29). The girls measured for the current study were, firstly, classified in five body sizes and later to 180 scoliotic groups, according to their different types of scoliosis. Finally, the subjects were re-classified into 90 scoliotic groups, after it was determined, based on medical data, that left and right scoliosis had the same clinical symptoms.
- The fourth phase involved the pattern adaptation and development for asymmetric bodies due to scoliosis, derived from each scoliotic group's median

measurements, using summary statistics that were established by six experimental studies. Concurrently, *grade rules* were developed in the PolypatternM2M software, for each of the four basic pattern styles, in order to produce mathematical formulas that addressed cardinal points the variation of body curvature, due to scoliosis.

- In the fifth and final phase of this research, the produced patterns were evaluated in two ways: 1) theoretically, based on the *aggregate loss of fit* (Gupta & Gangadhar, 2004:458-469) and 2) physically, made up into calico toiles for the two most populated scoliotic groups – representing the two most common types of scoliosis – that were then tested in a wearer trial. The patterns for the wearer trial were evaluated, based on my own visual fit assessment of the toiles, taking into account the participants' comments regarding the toiles' fit, after the wearer trial. For more reliable results, fit ratings from the garment trial were then compared to fit ratings from the '*aggregate loss of fit*' findings.

Relating the characteristics of clothes to the concepts of human anatomy, looking for a 'basic pattern block' ergonomically designed, this new pattern design approach would implement an innovative pattern design solution, while it could benefit apparel production for women with scoliosis in a customised level.

1.4.3. Research Objectives

Hence, the objectives of this research project are:

- To investigate the elements that determine the choice of fashion clothing from the adolescent girl's with scoliosis point of view - desires and needs combined with aesthetics, in order to enhance self-confidence.

- To examine the key role pattern and fashion design can play in enhancing the quality of life for adolescent girls whose bodies deviate from the norm, by developing new sets of pattern blocks for three different-severity scoliotic curve sizes, and thus, offer designers significant potential for creating innovative shapes in apparel pattern design, based on body asymmetry.
- To study the ethical issues that emerge in designing well-fitting patterns, focusing on ergonomics for asymmetric bodies, and on the way that these issues could be negotiated, drawing attention to aesthetics and self-expression.

1.5. A roadmap to the thesis

The thesis is divided into eleven chapters:

- Chapter 1 is an introduction to this thesis, involving the rationale behind the study, which derives from the author's personal experiences and quests evolving around beauty, disability and clothing, and includes the research questions, methodology, aims and objectives of this project, as well as, a brief description of the chapters that follow.
- Chapter 2 describes briefly the reason for the selection of the specific target group for this research and the physical dimensions of AIS – anatomy, aetiology, classification, assessment and treatment – leading to *subjects'* classification in 3 Scoliotic Curve Sizes.
- In Chapter 3, the concepts of *Disability*, *Body Image*, *Body Cathexis*, *Self-Esteem* and *Identity* are analysed from the literature, in relation to *the Media*, *Fashion* and *Clothing*, focusing on the psychological impact of clothing on girls with AIS and the issues of brand awareness amongst teenage girls. The research Questionnaire is also introduced, in this chapter, while research findings are

discussed, in order to illustrate a contemporary socio-cultural analysis of the factors that shape adolescent girls' *Body Image, Self-Esteem, lifestyle and preferences*.

- Chapter 4 provides a concise comparison of previous initiatives, current provision and approaches to design for the Disabled, or People with diverse Body Configurations and Needs, as well as of future design perspectives of fashionable clothing for females with non-standard body dimensions - including scoliosis. In this chapter, the emerging issues stemming from ergonomic fashion design are also identified, which point towards customisation and personalisation for the individual, using new technologies, such as the 3D body scanner.
- In Chapter 5, the need for clothing designed to conform to non-standard body figures, such as figures affected by scoliosis, is justified, applying an 'aesthetic' and an 'ethical' dimension in design.
- In Chapter 6, garment fit issues, 3D body scan technology and virtual try-on system developments are pinpointed, leading to an experimental study on body measuring methods, using the [TC]² 3D body scanner.
- Chapter 7 refers to the first phase of the research methodology: compilation of a set of measurements, figure analysis of a body affected with scoliosis, subject classification in relation to their Body Size and Scoliotic Curves and development of size charts based on young women's with scoliosis body dimensions, using summary statistics, PCA for determining the key factors, and consequently, the key dimensions, as well as frequency tables.
- Chapter 8 refers to the second phase of the research methodology: designing basic pattern blocks for women with scoliosis, including the appropriate ease allowances, pattern adaptations and development of grade rules, for pattern drafting, using the automated custom pattern design software *PolyPatternM2M*.

- Chapter 9 is a compilation of six experimental studies, conducted to determine the accuracy of the pattern blocks based on median measurements, derived by the *PolypatternM2M* software, investigating pattern design and grading issues.
- Chapter 10 refers to the last phase of the research, providing a consistent analysis of the results derived from the patterns' evaluation based on the 'aggregate loss of fit' and from the wearer trial evaluation done by the researcher based on subjects' comments, as well as a comparison between the two sets of evaluations, followed by the research conclusions.
- Overall, Chapter 11 describes the contribution to knowledge of this research, consisting of a list of this research project's limitations, potential value - in terms of cost and relevance to industry – as well as material for discussion and suggestions addressed to future researchers, based on the researcher's findings.

The thesis is also supplemented with data generated from the study of 75 subjects, tabulated in Appendices A to E (Tables are numbered with the chapter number they refer to). Certain Tables represent the results of statistical analysis, using standard tools available for Microsoft Excel 2007 (see List of Appendices, pp: xxvii).

Chapter 2

The Physical Dimensions of AIS

Scoliosis is defined as the presence of one or more lateral curves of the vertebral column in the coronal plane, although abnormal curves may affect spinal alignment in all three dimensions (Kotwicki, 2008:742-751). Scoliosis affects the entire skeletal system including the spine, ribs, and pelvis, while it may impact upon the brain and central nervous system, affecting the body's hormonal and digestive systems. The deformity may cause pressure on the nerves and possibly even on the spinal cord, leading to weakness, numbness, and pain in the lower extremities. In severe cases, pressure on the spinal cord may cause loss of coordination in the muscles of the legs, making it difficult to walk normally. Moreover, if the chest is deformed due to the scoliosis, the lungs and heart may be affected and damaged. This can cause breathing problems, fatigue, and even heart failure. Fortunately, these severe symptoms are rare (Larson, 2000).

The scoliosis size is usually determined by the measurement of the angle of the scoliosis curve, which is called the *Cobb-angle* (Cobb, 1948: 261-275). In patients with spinal curves of 25° or more, almost 90% are girls, and over 90% of idiopathic curves are convex to the right in the thoracic spine and convex to the left in the lumbar spine (Anderson, 2007: 44-65).

The main causes of scoliosis are: *congenital*, *neuromuscular* or '*paralytic*' and *idiopathic* (unidentified cause)⁵. *Idiopathic scoliosis* is the most common form, accounting for 80% of all scoliosis (Kim *et al.*, 2010:1823-1842). Its overall incidence is equal for boys and girls, although progression is much more severe in girls and seven times more frequent.

Idiopathic scoliosis is diagnosed after underlying causes are excluded and is generally further classified according to patient age and disease characteristics as infantile (age 0–3 years), juvenile (age 4–10 years), or adolescent (age 11–18 years). Adult-type idiopathic scoliosis is defined as idiopathic scoliosis that is detected after skeletal maturity has been achieved (Koutsostathis et al., 2005:315-322).

Current research shows that *Idiopathic scoliosis* is a structural curve, whose cause is unknown, while it is a multifaceted disease that compromises five of the body's systems: digestive, hormonal, muscular, osseous (bones), and neurological (Anderson, 2007:44-65). Radiography, computed tomography (CT), and magnetic resonance (MR) imaging, all can play important roles in evaluating scoliosis and determining its underlying cause (Cassar-Pullicino & Eisenstein, 2002:543-562). The true aetiology of Idiopathic Scoliosis remains unknown, but its cause is thought to be multi-factorial (Cobb, 1948:261-275). Aetiology is usually genetic, probably sex-linked inheritance with variable penetrance and expressivity. First-degree relatives have an 11% incidence of scoliosis compared to 3% in the general adolescent population (Inoue et al., 1998:212-217). *Idiopathic scoliosis* could be also related to equilibrium and postural mechanisms - factors that affect how the body is aligned. If a child has problems with posture, balance, and body symmetry, it could affect the way the spine is positioned. If the problems are chronic, it may disrupt the way the spine and muscles develop (Herman *et al.*, 1985:1-14). According to Coillard and Rivard (2001:1140-1141) an unsynchronized bone growth, in rapid growth and maturation situations, leads to the dysfunction of the neuro-musculo-skeletal system and scoliotic deformation. The spinal growth rate affects curve progression, which peaks before skeletal maturity is achieved, and the growth spurt is the main prognostic indicator of progression, although scoliosis may progress even after skeletal maturity (Kim *et al.*, 2010:1840).

⁵ http://adam.about.net/reports/000068_1.htm (Accessed 23rd May 2011)

In general, AIS is the type of scoliosis seen in girls from ten to eighteen years of age⁶ and is not generally progressive. Extremely active, athletic teenage girls with delayed menses are most at risk for curve progression, while most curves are right thoracic and thoraco-lumbar and have a strong tendency to progress during adolescent growth spurt (Lowe et al., 2000:1157-1168). Progression usually halts or is much slower at skeletal maturity, while the thoraco-lumbar junction develops much sooner than the upper thoracic region, which matures late and slowly. The corollary of this aspect, usually, is that any abnormality of the upper thoracic region has a potentially greater impact than the same abnormality appearing in the thoraco-lumbar or lumbar region (Coillard & Rivard, 2001:1140-1141).

Overall, AIS is preponderant in girls (male-to-female ratio, 1:4) and involves a structural curvature that is usually rightward trending (dextroscoliosis) (Silva & Lenke, 2009:97-118). The typical curve in AIS is a thoracic curve with right-sided convexity, with or without a compensatory lumbar curve with left-sided convexity (Kim et al., 2010:1839).

2.1. AIS determining the research sample's age scale

Today, it is estimated that the human form increases in height, from one to five years approximately 2.5 inches a year, and between the fifth and thirteenth year we may consider this increase to average 2 inches a year, whereas between the thirteenth and fifteenth year it becomes again 2.5 inches a year⁷. As Coillard & Rivard (2001) state, longitudinal studies of a child's growth point out that there are two major periods of growth and one of maturation. The first growth period occurs in the two or three first years of life, while the second covers preadolescence, intermingled with maturation of the adolescent whose morphology is suddenly perturbed. During these two periods of rapid growth, idiopathic scoliosis worsens most, particularly among girls. However, after

⁶ www.orthotic.com/scolio.html (Accessed 23rd October 2006)

maturity, reversing the condition is unlikely, contrary to the first period of growth. Very generally, each growth spurt starts by affecting the limbs, then the pelvis, next the chest, and finally the spinal column. At the start of the rapid growth period of preadolescence, notable variations in spinal column curvatures gradually and alternately wane – lumbar lordosis and then thoracic kyphosis – to gradually reappear at the end of the same period. During the period in which curvatures diminish, conditions of static and dynamic equilibrium of the spinal column necessarily vary. After the second period, longitudinal growth of the skeleton is immediately followed by a volumetric increase, particularly in girls whose pelvis expands, chest becomes larger and bones become more massive. (Coillard & Rivard, 2001:1140-1141).

Taken that rapid scoliotic curve changes occur during rapid spine growth period and scoliotic progression slows significantly at full maturity, it is essential to know when skeletal growth is complete to plan for therapy, follow up frequency, and cessation of therapy. In general, girls mature at about 16 ½ years old, thus, it is important to know the natural course of the curve, in order to determine the appropriate course of management. At the end of longitudinal growth, significant scoliotic progression usually ends. In some cases, scoliosis continues to progress approximately 1° to 2° degrees per year through adult life, causing significant disability at old age. These cases include patients with significant curves of more than 40° degrees, poor muscle tone, and women near menopause with osteoporosis. Adults with curves less than 30° degrees usually do not progress. In general, thoracic curves cause more deformity and disability, while the earlier the age of onset, the greater the deformity and disability later in life (Tran, 1997). Therefore, in this research project, the selected sample consists of females between 16-22 years of age, diagnosed with AIS, because they had to be in their late-puberty, so that their bodies would have developed an almost full female figure. I also wanted to focus on

⁷ www.nlm.nih.gov/medlineplus/ency/article/001950.htm (Accessed 9th February 2009)

this specific age group, because girls of this age are not as mature as older women are, when it comes to selecting clothes for a good fit, and can easily get carried away, in terms of misjudging fashionable, or trendy clothing, that might not fit them properly.

2.1.1. Sample Characteristics

All the *subjects* (participants) measured for this study, were fairly well distributed geographically with 74% living in a city, 19% in a town and 7% in a village (Table 2.1a). Ninety percent lived with their parents, 4% with a partner and another 6% lived with other family members (grandmother, aunt, siblings, etc) (Table 2.1b).

Only 5 subjects stated that they had a permanent job, working on a daily basis, the remainder being secondary school or college students. Therefore, the former is one group, which is clearly under-represented in this study. Greek European girls formed 100% of the sample. Nearly half of the sample (42.6%) was between the ages of 16 and 17 years, while exactly one third of the sample (33.4%) were between the ages of 21 and 22, and another one quarter (24%) between the ages of 18 and 20 (Table 2.2).

Table 2.1a

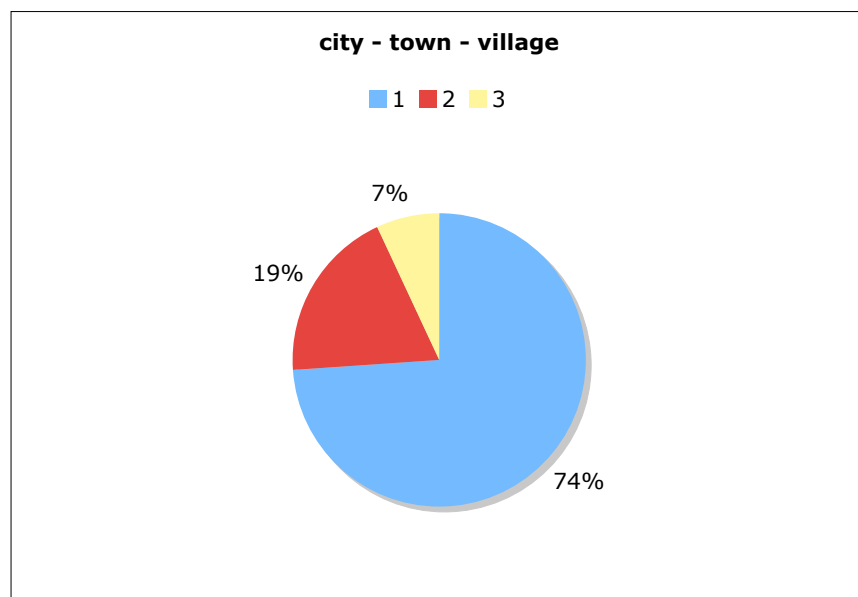


Table 2.1b

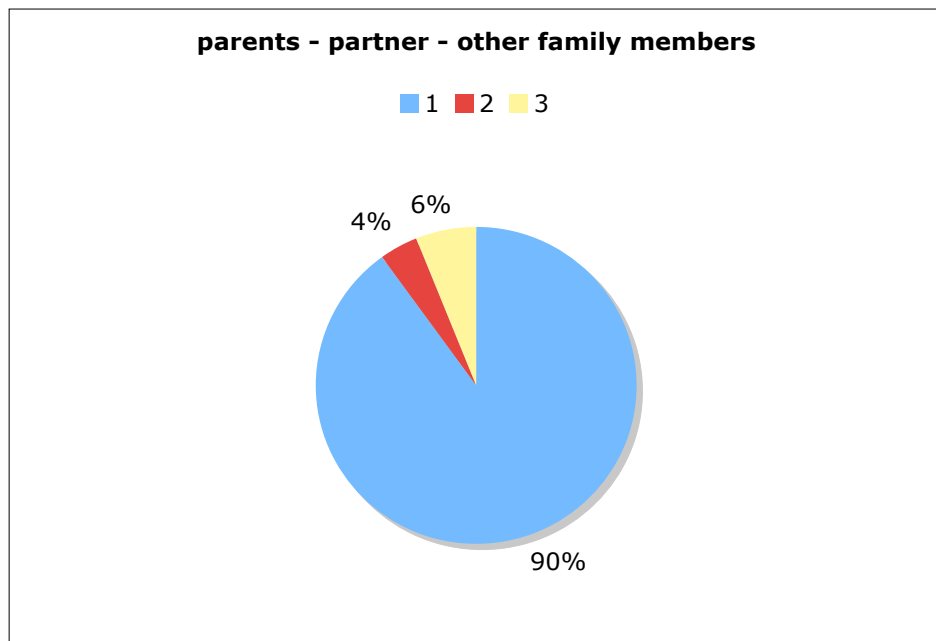
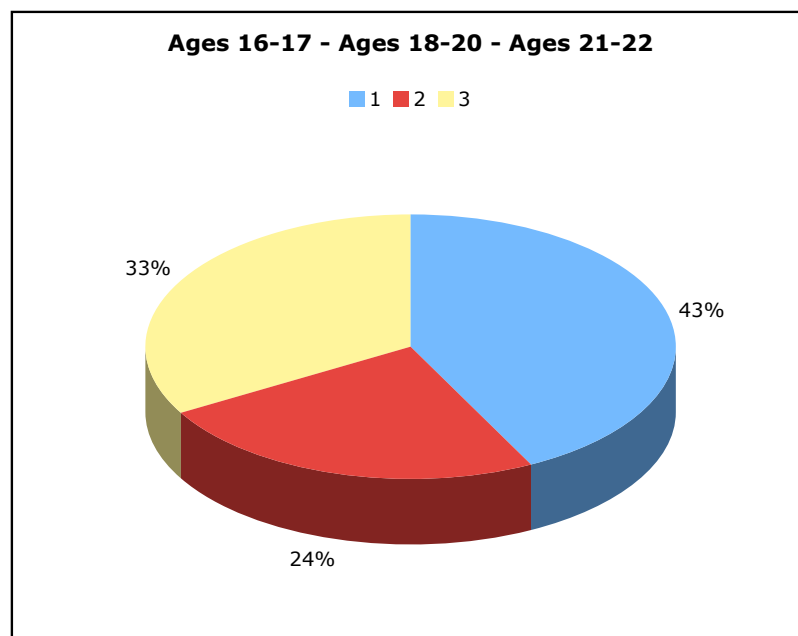
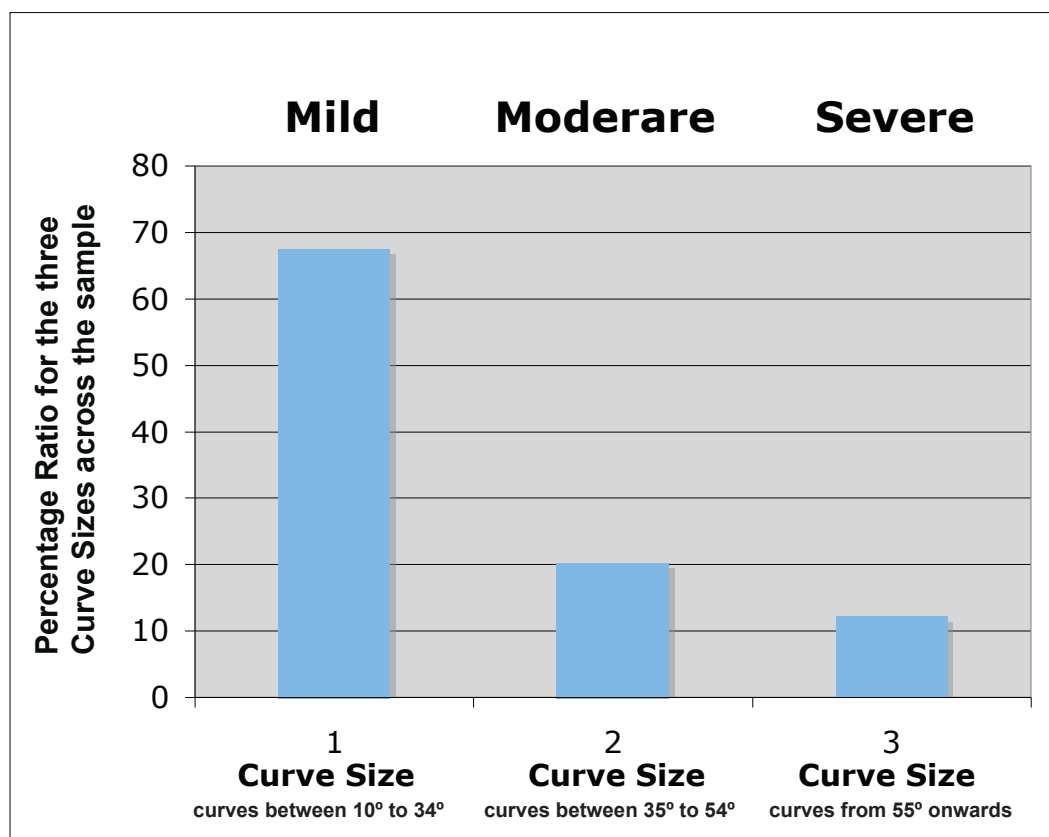


Table 2.2



More than two thirds of the sample presented a mild spinal curvature (67.56%), while subjects with a moderate spinal curvature represented 20.27% of the sample, and those presenting a severe spinal curvature covered only 12.16% of the whole sample (Table 2.3). ‘Mild’, ‘moderate’ and ‘severe’ scoliosis refer to the magnitude of scoliosis, according to which, subjects in this research were classified in three Curve Size categories – Curve Size 1, Curve Size 2 and Curve Size 3 (see Chapter 2.5:40).

Table 2.3



The percentage ratio in Table 2.3 is rather typical, owing to the fact that, in general, the prevalence of curves between 10° to 30° is 2-3%, whereas that of curves greater than 30° is approximately 0.2% (Roach, 1999:353–365) and that of curves greater than 40° is approximately 0.1% (Miller, 1999:343–352).

2.2. Body Asymmetry as a result of AIS

When the patient diagnosed with AIS is observed in standing position from behind for an evaluation of truncal alignment or torso displacement, asymmetry can be easily noted as evident by asymmetry of the shoulder height, in-folding of skin and prominence of the iliac crest on the concave side, shifting of the thoracic cage and prominence of the anterior chest on the convex side (due to anterior rotation on the convex side).

The degree of rotation of the spine, due to scoliosis, is assessed in the bent position by noting prominences in the thoracic and lumbar areas (Anderson, 2007:44-65) (see Figure 1.5, Right). The vertebra turn toward the convex side and rotate toward the concave side, in the area of the major scoliotic curve. As the vertebra rotate, they push the ribs on the convex side posteriorly, and at the same time, crowd the ribs on the concave side together, as well as push them anteriorly. The posterior displaced ribs cause the characteristic *hump* in the back with forward flexion, which has a result an apparent body asymmetry, especially of the torso. Thus, a postural misalignment is created: the ribs are rotated, the shoulders can be at different heights with one shoulder blade more prominent than the other, and one hip may be higher than the other, resulting in an uneven waist (Anderson, 2007:44-65). The head is sometimes not centred directly above the pelvis and the entire body can be leaning to one side (Figure 1.4).

Careful measurement of children using anthropometry in Liverpool and Nottingham, UK, has demonstrated that the children affected with scoliosis have considerable directional asymmetry affecting the skull, jaws, upper limb and pelvis (Manganiello, 2000:423-429), while an asymmetric pelvis can lead to trunk imbalance and may make the patient appear as though listing to one side (Figures 1.4 & 2.1). According to Proceedings of *the 6th Scoliosis Symposium* (1977:30-34), the presence of torsional asymmetry in the lower limb is indicative, while growth is itself different from normal, with some adolescent girls

often being skeletally immature but unusually tall for their age. Young girls with scoliosis often complain of unequal breasts, due to recess of the chest wall on the convex side of the curve. Scoliosis can also cause rib prominence on one side and leg length discrepancy, which often results in gait dysfunction. Investigation of the gait of scoliotic subjects reveals that abnormal forces are present in the gait cycle, highly suggestive and supportive of concepts of a neurological factor involved in the development of scoliosis (Proceedings of the 6th Scoliosis Symposium, 1977:30-34).

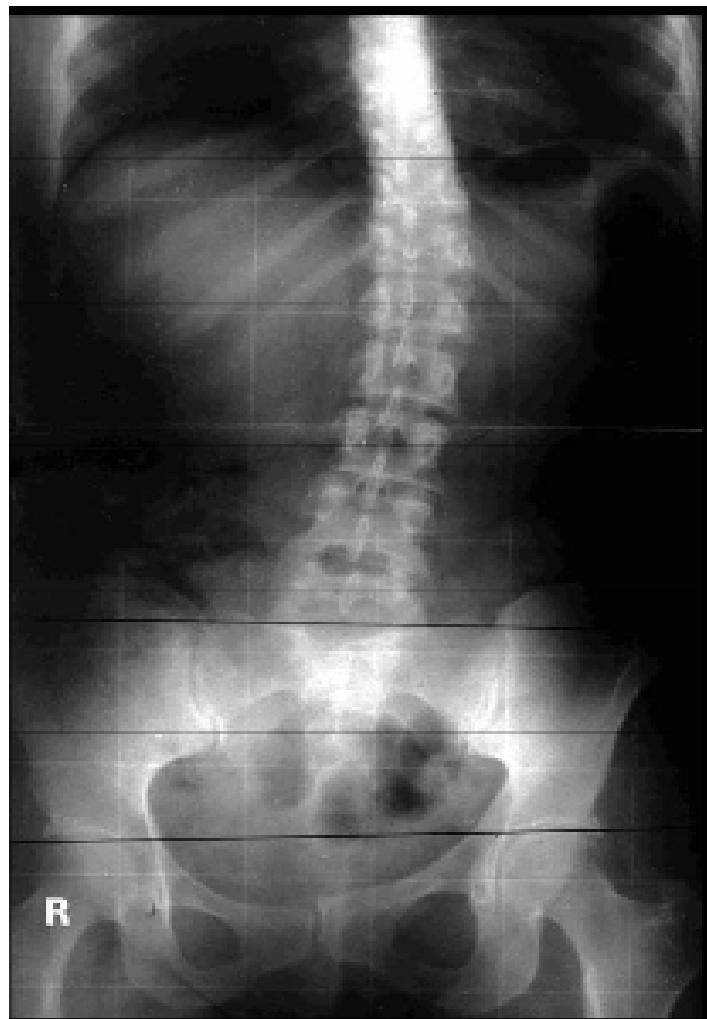


Figure 2.1. Leg Length Inequality: Anterior rotation and torsion of the left ilium, with consequent asymmetric drop of the sacral base

2.3. Types of Scoliotic Curves

The types of curves noted in a scoliotic spine are i.e, left versus right and C-T-L (Cervical, Thoracic, Lumbar), or combination (cervico-thoracic, thoraco-lumbar or cervico-thoraco-lumbar). Curvature can take place anywhere along the length of the spinal column, however there are 3 most common patterns of curvature:

- Right thoracic Scoliosis indicates that the major scoliosis is concentrated in the thoracic (mid-back) region and curves to the right (Figure 2.2). *Right thoracic* are the most common **C**-type curves and can develop rapidly, if not treated early, bound to cause severe cosmetic deformity. Cardio-pulmonary compromise will ensue when curves reach 60°. In the right thoracic scoliosis there may also be a counter curve to the left in the lumbar (lower back) region, but this is, usually, a less severe curve (Tran, 1997).
- Left lumbar Scoliosis indicates that the major curve is to the left and is concentrated in the lumbar region (Figure 2.2). This is also known as a **C**-type curve. There may be an opposite curve less extreme to the right in the thoracic region. *Lumbar major curves* are less common, while they are not deforming but can lead to disabling back pain in later life and during pregnancy (Tran, 1997).
- Right thoracic-left lumbar Scoliosis The last type of curvature is the combined curve where the major curve is in the thoracic region with an equal counter curve to the left in the lumbar region (Figure 2.3). This is commonly known as an **S**-type curve. *Thoraco-lumbar curves* are also common, while they are usually not as deforming (Tran, 1997).



Figure 2.2. Types of scoliosis (Right Thoracic and Left Lumbar)

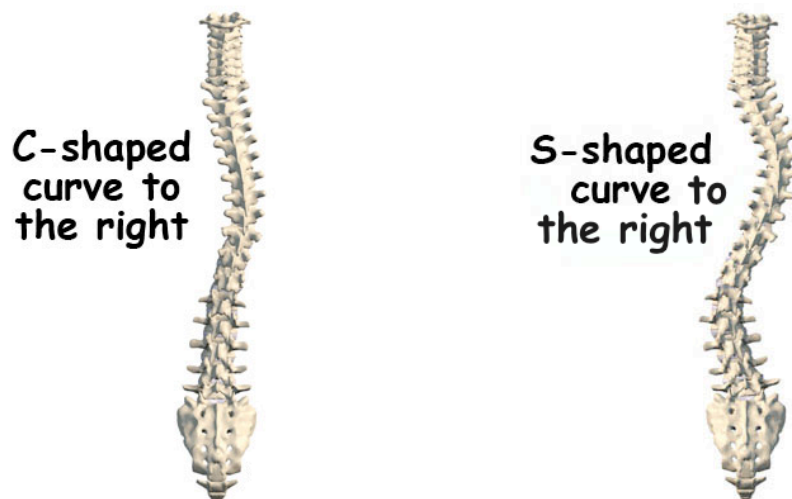


Figure 2.3. C-shaped Right Thoracic Scoliosis – S-shaped Right Thoraco-lumbar Scoliosis

For unknown reasons, 90% of thoracic curves are right convexity (curve to the right); 80% of the thoraco-lumbar curves also are right convexity; and 70% of the lumbar curves are left convexity. Double Major Curves are right thoracic and left lumbar curves equal in size. There can also be triple curves with an additional lateral curve in the cervical or neck region. Moreover, two or more lateral curves can be in the thoracic region of the back with a major lumbar curve (Information provided by the official *Massachusetts General Hospital* website).

Therefore, scoliosis can be further described as:

- *Right or Left*: defined by the side of convexity of the curve, i.e. right scoliosis has the convex side toward the right.
- *Cervical, Cervico-thoracic, Thoracic, Thoraco-lumbar, Lumbar, Cervico-thoraco-lumbar*, describing the region where the scoliotic curve is located (i.e. when the curve is located in the cervical spinal region, then the type of scoliosis is called '*cervical scoliosis*').
- *Single or Compound*: Single has one-sided spinal deviation (C-type), whereas compound has both right and left spinal deviations (S-type).
- *Primary (Major) or Secondary (Minor)*: Primary describes the initial curve that can later be compensated for by a curve in the other direction (secondary scoliosis). Major curve denotes the greatest curve, which is often accompanied by a minor curve, usually a compensatory curve (or curves) in the other direction, above and below the major curve. Sometimes, the compensatory curve is as large as the major curve; in this case, it is called a *double major curve*.
- *Structural or Functional (Non-structural)*: Scoliosis can be either structural or functional (non-structural). To determine whether a scoliosis is functional or

structural, the patient has to bend forward from the hips. If a lateral (side to side) curve visible in standing disappears in this position, the scoliosis is functional; if the curve remains, it is built into the ribs and spine, and the scoliosis is structural.

Two main classification systems are used for the anatomic and morphologic description of curves in adolescent idiopathic scoliosis: one devised by King and colleagues (King *et al.*, 1983:1302–1313), and another devised by Lenke and colleagues (Lenke *et al.*, 2001:1169-1181). Both systems are used to guide surgical treatment, with the Lenke system being more widely used, due to the fact that it includes not only thoracic curves but also thoraco-lumbar and lumbar curves, it describes sagittal curves, which are neglected by the King classification system, and it allows higher rates of inter-observer and intra-observer agreement than are achievable with the King system (Lenke *et al.*, 1998:1097–1106).

2.4. Assessment of AIS

Scoliosis is clinically apparent by observing the asymmetry of spinous processes, ribs, and scapulae, as well as the lateral imbalance and the left–right asymmetry (Reamy & Slakey, 2001:111–116) of the trunk. Beyond the clinician's eyes and simple tools such as the measuring tape, numerous techniques help physicians in scoliosis diagnosis and monitoring. Historically, the surface deformity has been analyzed with inclinometers and plaster casts of the back (Stokes & Moreland, 1989:73–78).

Most curves can be treated non-operatively if they are detected before they become too severe. Therefore, scoliosis screening is done in schools, by physical examination with the Scoliometer, and should start at the age of 10-11 years, and every 6 to 9 months thereafter. If scoliosis is detected in a child, all siblings should be screened due to the

hereditary nature of the condition (Sahlstrand & Petruson, 1979:759-769). If there is a significant change over the previous 6 months or if there is a severe rib rotation, X-ray is then warranted to determine the physiological or skeletal maturity of the patient.

Several methods to quantify the scoliotic deformity from back or trunk surface asymmetry have been introduced since the 1970s: Moiré contour topography (Moreland, Pope & Wilder, 1981:129–132), raster systems such as the ISIS (Weisz, Jefferson & Turner-Smith, 1988:405–408; Tredwell & Bannon, 1988:1104–1105) or the Quantec scanner (Goldberg *et al*, 2001:E55–E63; Thometz, Landan & Liu, 2000:512–516). The value of quantifying not only the back surface but also the 360° deformity of the entire scoliotic trunk has also been investigated (Dawson, Kropf & Purcell, 1993:326–331; Ishida, Mori & Kishimoto, 1987:583–585; Gomes, Serra & Lage, 1995; Sciandra, De Mauroy & Rolet, 1995), while each new technology introduces a different approach to understanding scoliosis via a different set of data describing the spine or the trunk.

In Greek Hospital settings, scoliosis is measured according to the Cobb Angle Method. The Cobb angle (Figure 2.4ab & 2.5) is the technique most frequently used by clinicians to measure scoliosis because it provides a standard measure of scoliosis curvature and is primarily used in deciding on a treatment method for scoliosis (Cobb, 1948: 261-275). To use the *Cobb method*, firstly, the *end-vertebrae* of the curve – i.e. the vertebrae at the upper and lower limits of the curve, which tilt most severely toward the concavity of the curve (Kim *et al.*, 2010:1823-1842) – should be defined. Once these vertebrae have been selected, two lines are drawn: one along the upper endplate of the upper body and one along the lower endplate of the lower body, (dotted lines) as shown in Figure 2.4a. The angle of interest is the angle between these two lines. To facilitate the measuring, when dealing with minor degrees of scoliosis, a useful trigonometry theorem can be applied to help measure this angle: If two perpendicular lines to these first two lines are

constructed, these perpendicular lines will intersect on the radiographic film and will have the same angle between them as exists between the first two lines (Figure 2.4). When reporting this angle, after having been plotted digitally or manually (Kim *et al.*, 2010:1823-1842), it is important to mention that one is using the *Cobb method* and also which *end vertebrae* were chosen for the measurement. This latter data is especially important, since once chosen, the same levels should be used from then on to measure curvature on follow-up films. This information should be in the radiographic report, since it becomes part of the patient's chart and therefore lasts far longer than the radiographs, which are often recycled after 5 years or so.

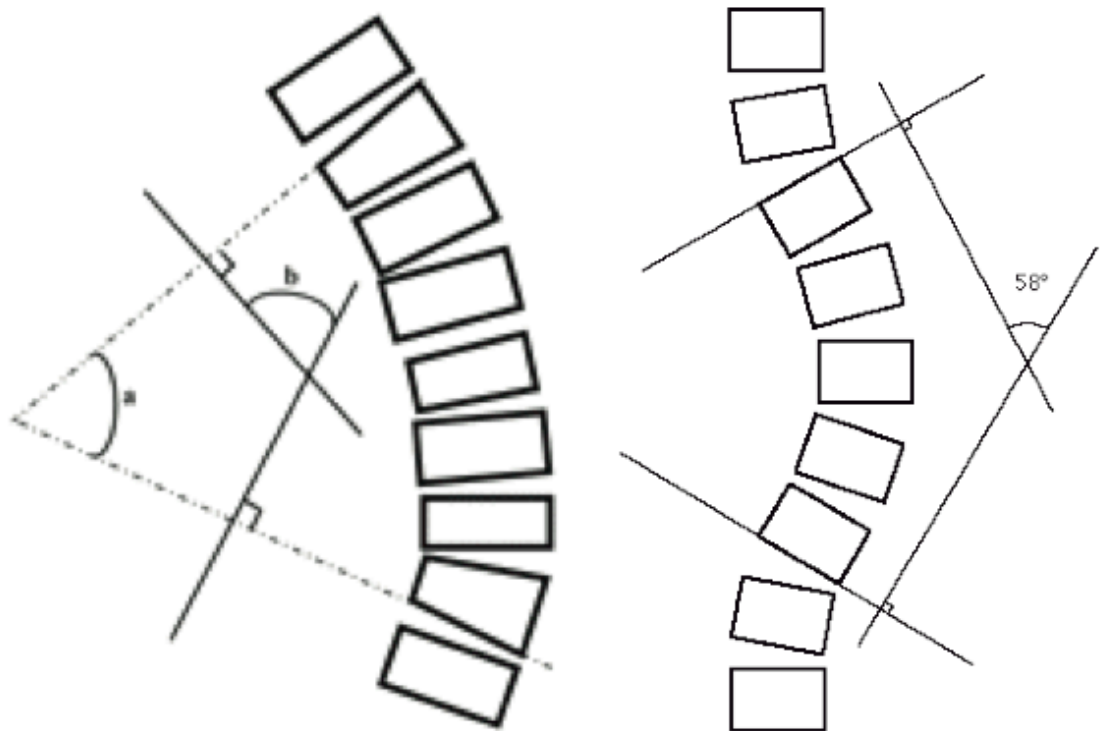


Figure 2.4a. Measuring the Cobb-angle

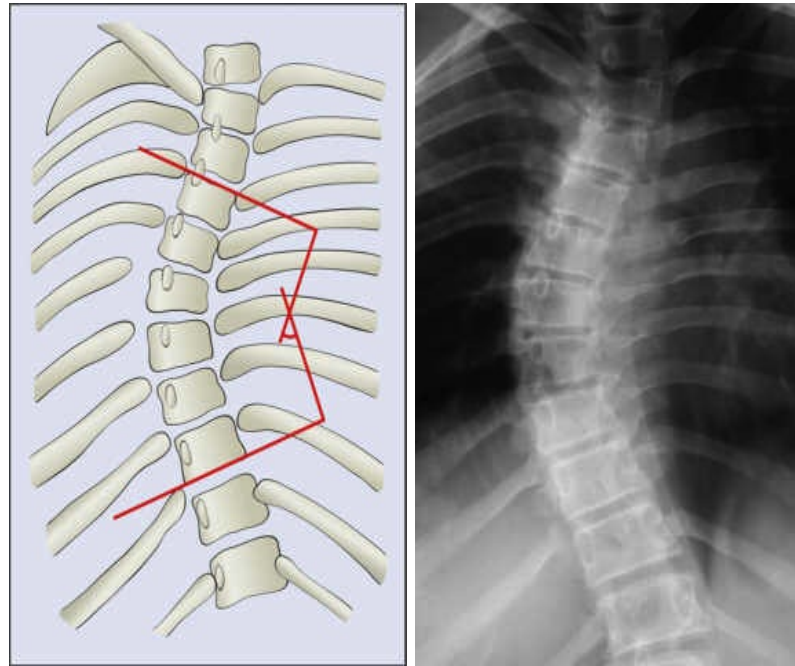


Figure 2.4b. Measuring the Cobb-angle

The *Cobb method* has several advantages over other methods, especially due to the fact that it is more likely to be consistent, when a patient is measured by several different examiners. Its most important limitation, however, is that it uses a two-dimensional radiographic image of a 3D deformity, without taking vertebral rotation into account (Kim *et al.*, 2010:1823-1842).

In general, AIS is a three-dimensional deformity of the spinal column and associated rib cage (Dubousset, 1994:479-496), while such a coronal and sagittal deformity is typically quantified using 2-dimensional radiographs (Cobb, 1948:261-275). To date, in Greek hospital settings, scoliosis is measured according to the *Cobb Angle* method, utilizing 2D lateral measures to register the deformity. Transverse plane vertebral rotation of the deformity can be assessed using radiographs (Bunnell, 1985:114), ultrasound (Suzuki *et al*, 1989:252-255) and Magnetic Resonance Imaging (MRI) (Birchall *et al*, 1997:2403-

2407), but the gold standard is axial computed tomography (CT) (Ho *et al*, 1992:771-774).

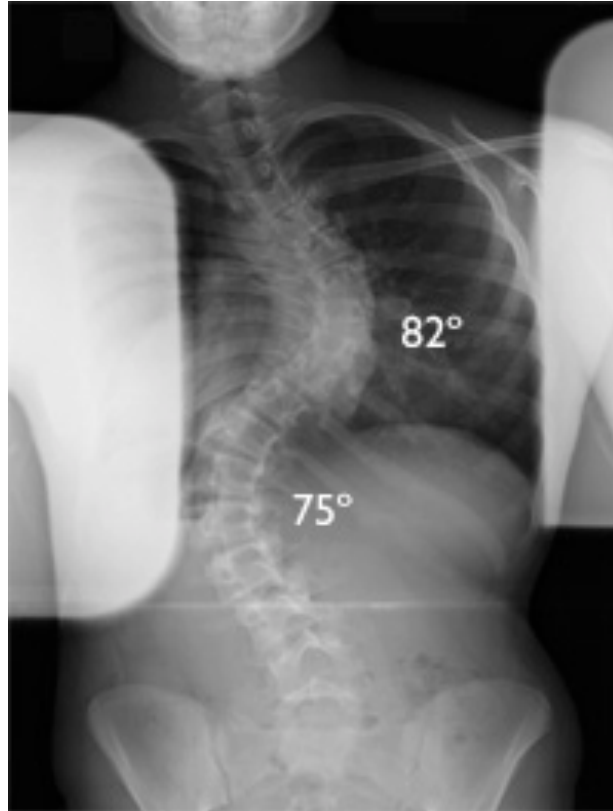


Figure 2.5. This x-ray of a patient's scoliosis, measures 82° in the upper (thoracic) curve, and 75° in the lower (lumbar) curve (Courtesy of Texas Scottish Rite Hospital for Children)

Since the invention of the Scoliometer – a useful measurement device that can detect scoliosis and abnormal antero-postero curves, while it also measures the unstable lumbo-sacral, cervical and thoracic curves, with scales in centimeters, inches, and degrees – there has been a push towards finding a reliable and effective means of utilizing surface topography to follow spinal curve progression in patients with AIS (Parent *et al.*, 2010:78-82). Surface topography has obvious advantages to repeat radiographs in the adolescent population, importantly the reduction in exposure to ionizing radiation (Frerich, Hertzler, Knott, & Mardjetko, 2012:262).

A study by Samuelsson and Noren (1997:273-276) found that a criterion of > 7 degrees angle of axial trunk rotation (ATR) for thoracic or right convex curves and one of > 6 ATR for thoraco-lumbar and lumbar or left convex curves seem adequate for identification of patients with Cobb angles of 25 degrees or more, which reduces the need for spinal radiography and follow-up outside the school screening programs.

Overall, the *Formetric 4D surface topography system* (Figures 2.6 & 2.7) was compared to standard radiography as a safer option for evaluating patients with AIS (Frerich, Hertzler, Knott, & Mardjetko, 2012:261-262), and proved to be comparable to radiography in terms of its test-retest reproducibility. This system permits rapid static and dynamic (functional) optical measurement of the human back and spine, while the procedure is radiation-free and operates without contact and whereby, numerous clinical parameters for objective analysis of body statics, posture, scoliosis, and all forms of spinal deformities can be shown. The new 4D technology leads into functional clinical measurement technology, to increase measurement precision (4D averaging) and to avoid postural variances. Although this device does not predict curve magnitude exactly, the predictions correlate strongly with the Cobb angles determined from radiographs, while it can be reliably used in the surveillance of patients with AIS (Frerich, Hertzler, Knott, & Mardjetko, 2012:261).

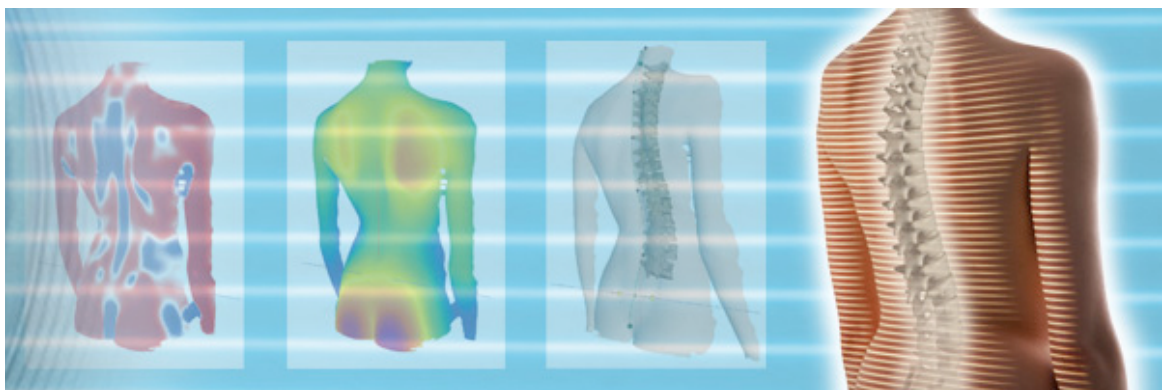


Figure 2.6. The Formetric 4D system by Diers Medical Systems, developed in Germany, has been used extensively throughout several European countries since 2007

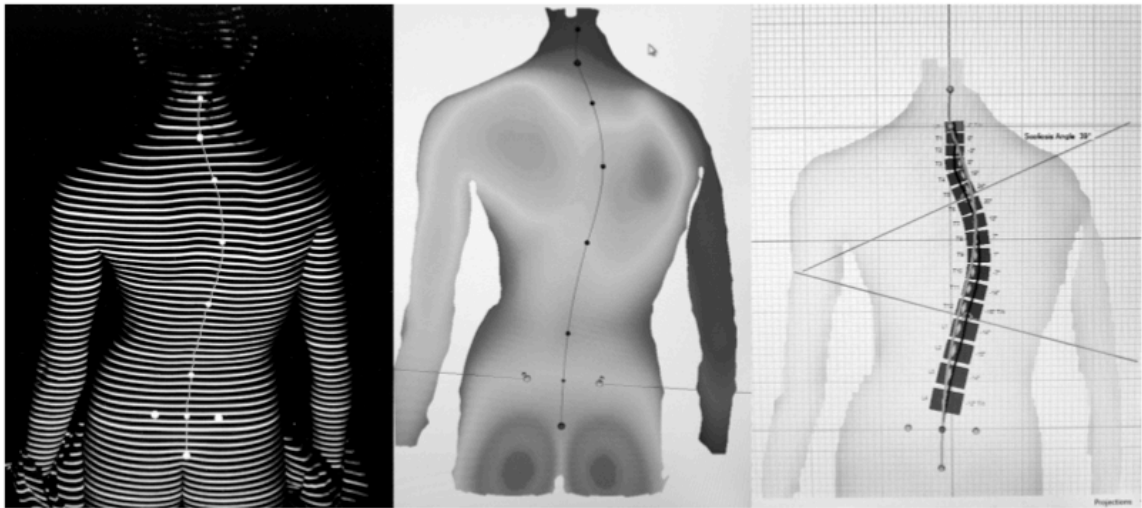


Figure 2.7. Topographic analysis and software output from the Formetric 4D device

Therefore, there is an increasing need for an objective and less invasive assessment to monitor treatment effectiveness. As cosmetic appearance is a serious concern for the patients (Goldberg *et al*, 2001:E55–E63; Pratt, Burwell & Cole, 2002:1543–1552), it is important to develop more reliable tools to assess spinal posture and back shape, since current tools for measurement are either unreliable or too complex.

A study by Pazos *et al*. (2007:1882-1891), investigating the reliability of trunk shape measurements, found out that in spinal deformities the trunk deformity needs more than a single value index to be described adequately. Thus, surface asymmetry analysis, based on 3D surface reconstructions, should be seen as a dashboard to monitor the status and evolution of a scoliotic deformity, whereby main indices are the back surface rotation and the axial trunk rotation, as they seem similar in their definition, but they do not measure exactly the same characteristic. Axial trunk rotation measurement (ATR) includes also the anterior profile that contributes to the perception of cosmetic deformation. With a combined interpretation of these two measures, it would be possible to differentiate the axial rotation of transversal sections and their deformations. Together, they would provide a more adequate characterization of the rib cage deformity, while to

detect a progression it would be more appropriate to compare curves, representing measurements along the trunk length, rather than just considering single maximal values, because they would provide indications on the extent of the rib cage deformity. Hence, external measurements can provide non-invasive complementary evaluation of changes in external asymmetry. If not sensitive enough to detect smaller changes for natural progression monitoring, trunk surface analysis can still document the external asymmetry associated with different types of spinal curves and could provide a 3-D classification of scoliotic deformities (Pazos *et al*, 2007:1882-1891).

Thus, in this research project, it was determined that the issue of rotation of the vertebral column should be addressed by measuring the front and back arc measurements, as well as the right and left arc measurements, separately, instead of just taking circumference measurements, in order to register the three-dimensional (3D) body shape of a young girl with scoliosis, by measuring the external body asymmetry.

2.5. Subject classification in 3 ‘Scoliotic Curve’ Sizes, conforming to the magnitude of the deformity

Although many adolescents have scoliosis, it is estimated that only 10% of patients have a curve that progresses to the point of requiring medical treatment. Most natural history studies that have examined curve progression, involved females, primarily with thoracic curves. These patients’ ages and initial curve magnitudes were factors closely related to the likelihood of curve progression (Stephens-Richards *et al.*, 2005:2068-2075): patients with curves between 20° and 29° are significantly more likely to have more than 5° curve progression when compared to those in similar age groups with curves 5° to 19°, especially for younger females. Skeletal maturity is also important when considering the

risk of curve progression, while the likelihood of more than 5° progression is significantly higher for patients who are skeletally immature (Stephens-Richards et al., 2005:2068-2075). Overall, only 5% of adolescent patients with idiopathic scoliosis experience curve progression beyond a Cobb angle of 30° (Van Goethem & Van Campenthout, 2007:95-108). If scoliosis is neglected, the curves may progress dramatically, creating significant physical deformity and even cardio-pulmonary problems with especially severe curves; patients who have a curve with a Cobb angle of more than 50° have higher rates of back pain and mortality associated with cardiopulmonary complications (Weinstein SL, Zavala DC & Ponseti IV, 1981:702–712).

The recommended treatment for adolescent and adult idiopathic scoliosis is, thus, observation (follow-up at 4- to 12-month intervals) when the Cobb angle is less than 20° in AIS and less than 30° in adult idiopathic scoliosis, bracing when the Cobb angle is 20°–45° in AIS, and surgery when the Cobb angle is greater than 45° in both adolescent and adult idiopathic scoliosis (Kim *et al.*, 2010:1841).

Hence, primarily, subjects in this research were classified (by me, as the researcher) in three different groups, according to the treatment of their scoliotic deformity: *Group 1* covered subjects from 0-20° (no brace need), *Group 2* covered subjects from 20-45° (bracing), and *Group 3* covered subjects from 45° onwards (surgery need if growth time remains) (Winter, 1994:195-204).

Nevertheless, Prof. Christodoulou, my advisory consultant in Greece, suggested that it would be wiser to proceed in a *curve size classification*, related to pattern profile and garment fit, since body asymmetry is apparent beyond 10° (Cobb angle), insisting that there are a number of people with severe scoliosis (over 60°), that do not wish to undergo surgery and continue living in severely deformed bodies.

Therefore, the curve size analysis and how it was affecting body shape was the starting stage of this study, in order to develop an improved patternmaking approach. The final curve-size classification, under guidance from Prof Christodoulou, was formed as follows (Appendix B – Curve Table):

- Curve Size 1 covered subjects from 10-34° presenting a mild spinal curvature (Figures 2.8 & 2.9, left figures)
- Curve Size 2 covered subjects from 35-54° presenting a moderate spinal curvature (Figures 2.8 & 2.9, middle figures)
- Curve Size 3 covered subjects from 55° onward presenting a severe spinal curvature (Figures 2.8 & 2.9, right figures)

Figures 2.8 & 2.9 depict the three different-severity *scoliotic curve sizes* for the two most common types of AIS: Right C-type Thoracic and Right S-type Thoraco-lumbar.



Figure 2.8. Three different-size curves for Right, C-type, Thoracic Scoliosis

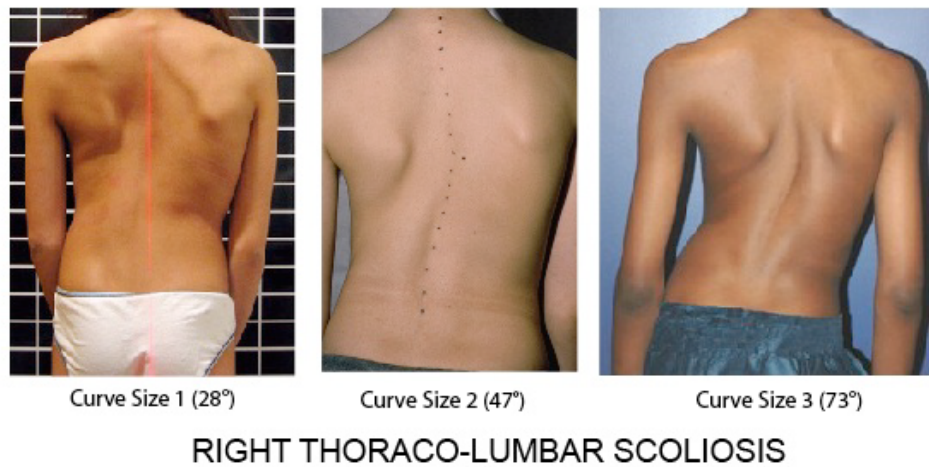


Figure 2.9. Three different-size curves for Right, S-type, Thoraco-lumbar Scoliosis

As scoliosis is a 3D deformity, however, current 2D measuring methods (Cobb angle) seem inadequate, since it was reported by Pazos *et al.* (2007:1882-1891) that for two right thoracic scoliotic deformities with equal Cobb angle, their external asymmetries were significantly different, at least statistically.

Further classifications, based on body shape asymmetry are, therefore, needed (see Chapters 7.5.2:271 & 7.5.3:276), in order to document the external asymmetry associated with different body sizes, shapes and types of spinal curves, providing a 3D classification of scoliotic deformities.

Chapter 3

Perceptions of Body Image in Adolescence, the role of the Media and the impact of Clothing on girls' with AIS Identities –

Initial data collection by a questionnaire and findings

3.1. Perceptions of Body Image in Adolescence

Body image is a subjective picture of one's own physical appearance, established both by self-observation and by noting the reactions of others⁸, while this conception may or may not correlate with objective reality. The psychological construct of body image includes cognitive and emotional aspects as well as sensory input: one modifies their ideas of their own bodies according to their emotional state as well as the reactions of others in the environment. Each person holds an image of the physically perfect person in mind and evaluates his or her appearance against this ideal. A person who is pleased with his or her body shape and appearance is said to have a positive self-image (School of Medicine, New York University, 2002)⁹.

The '*Body Cathexis Scale*', developed by Secord and Jourard (1953:343-347), had pointed out that body satisfaction was highly associated with general self-esteem. A person who scored highly on the Body Cathexis Scale would also be likely to score highly on self-esteem scales. Jourard suggested that a high degree of '*body cathexis*' (ratings of body parts) would contribute to an individual's acceptance and approval of his or her own overall personality. Evaluative feelings about the body would affect the individual's psychosocial, social and physical exchanges with the environment. Hence,

⁸ <http://www.merriam-webster.com/medical/body%20image> (Accessed 14th May 2013)

there is a high correlation between body-cathexis (ratings of body parts) and self-cathexis (ratings of aspects of self). Personal appearance is a means to many highly valued ends in our society, and, if a person is not physically attractive or perceives himself or herself as unattractive, his or her access to these goals is diminished, leading to anxiety and a general self-devaluation (Jourard & Secord, 1954:184).

Adolescent girls are at an exciting time in their lives, growing physically, mentally, and emotionally, while it can also be a confusing time, as they try to come to terms with various physical and emotional changes, such as breast development, growth of pubic hair, widening of the hips, onset of menstruation, etc., which may make them feel uncomfortable with their new bodies. Therefore, adolescent girls' good looks are particularly important for women's later vision of themselves and their happiness, owing to the adolescents' realistic attitude towards their appearance and their considerable appearance-related psychological problems, when dissatisfied with their body parts that do not appeal to them (low body cathexis). Good looks remain important throughout the lifespan in shaping self-esteem and a positive body image, in preserving happiness, and in determining the way they will be treated by others.

Much of the research on body image has been conducted on adolescents as this developmental period is not only one of great physical change but also the time that teens begin to subject themselves to (often painful) scrutiny. In a study by Rosenblum & Lewis (1999) body image, objective physical attractiveness, and body mass index was measured in 115 boys and girls at ages 13, 15, and 18, and it was found that across the same period in adolescence, girls' body image worsened while boys' improved. At age 13, the differences between the sexes were not dramatic, but the gap had widened considerably by age 15. Rosenblum & Lewis (1999) also pointed out that as a normal

⁹ http://www.aboutourkids.org/files/articles/mar_apr_2.pdf (Accessed 16th August 2012).

consequence of puberty, girls experience an increase in body mass with an accumulation of fat around the hips and thighs. This '*filling out*' creates a disparity between the cultural ideal of slimness and the actual body type (Rosenblum & Lewis, 1999:50-64).

Dissatisfaction exists in a context where body image is subjective and socially determined. Data from different social groups show that the same body shape may be perceived more or less positively depending on the gender and social group of the person doing the perceiving (Grogan, 1999). The '*1997 Psychology Today Body Image Survey*'¹⁰ of 4,000 men and women asked participants about attitudes towards their physiques and specific body parts. 54% of the girls aged 13-19 revealed that they were dissatisfied with their overall appearance, while these figures were much higher than those reported in previous surveys conducted by the same magazine in 1972 and 1985. In addition, Stevens & Tiggemann (1998) have studied the silhouette choices of women, whereby body figure preferences were examined in a sample of 180 women 18 to 59 years old. Participants of all ages rated their current figure as significantly larger than their ideal figure, indicating the presence of body dissatisfaction across the life span. The degree of body dissatisfaction did not vary with age, marital status, educational level, or occupational status, while it was established that body satisfaction does not relate to actual body shape and size (even for people living in the same culture) (Stevens & Tiggemann, 1998:94-102). The factors that seem to predict body satisfaction most accurately are social experiences, self-esteem and perceptions of control over one's life - including perceived control over the body (Grogan, 1999).

Once an individual's perceptions of this body image are altered, emotional, perceptual and psychosocial reactions can result (Kolb, 1975:810-837). The perceived discrepancy

¹⁰ The 1997 'Body Image Survey' Results. Psychology Today. Jan-Feb, 1997.

between the altered physical state (i.e. caused by a deformity of the spine), and the former (ideal) physical state produces emotional tension, experienced as anxiety, which becomes chronic as long as the discrepancy continues (Henker, 1979:812-820). This established the findings by Barker *et al.* (1953:55), who had studied the severity of the disability and found significant differences in self-esteem in groups of mildly, moderately and severely disabled people.

Lipowski (1977), on the other hand, had stated that individuals value certain body parts or functions for several reasons: they provide a source of self-esteem or sense of competence; help contend with the environment; enhance self-concept acceptability of body image and allow the individual to continue social, sexual and vocational functioning. Sometimes the value has unconscious symbolic meaning, which imparts of it a vital value, while any disability/body deformity that disrupts any of these personal values will have a deep psychological effect on the individual (Lipowski, 1977:473-479). The degree of emotional reactions to body dysfunction correlates with the subjective value and meaning placed on the body-part – both conscious and unconscious – and not the severity of the pathology or lost function (Shontz, 1975).

More recently, Breakey (1997) argued that blossoming of the body image is integrated with the socialisation process, which involves internalisation of social standards of attractiveness, capability and normality. Individual development of a positive or negative body image is thus influenced by the perception of oneself relative to these standards. Since the body creates the first impression, eliciting a large amount of feedback on which feelings of self-esteem are built, it is understandable a relationship would be seen between body image and self-esteem, and also, probable that a disfigurement/deformity leaves the victim with impaired self-esteem and impaired social and economic opportunities (Breakey, 1997:107-112).

Body-related attitudes of groups of women who suffered from physical conditions, commonly regarded as being disfiguring and/or disabling, were also studied by the means of the Body Attitudes Questionnaire (BAQ), by Ben-Tovim & Walker (1995). Despite their conditions, the women who took part in the survey did not necessarily disparage their bodies, while they seemed to worry less about small changes in weight and shape than did comparable women without physical difficulties. There was an indication that development of negative body attitudes might be linked to emergence of a chronic physical condition during adolescence, rather than from birth or during adulthood. The results of this study pointed to the need to pay special attention to the psychological needs of women whose bodies become dysfunctional at this sensitive time (Ben-Tovim & Walker, 1995:283-291).

3.2. The Impact of Clothing on Adolescent girls' Body Image and Identity

Schilder (1950) had postulated that body image is in a continuous process of enlargement and shrinking, and that all individuals enjoy these changes in it, while according to Freud (1923:1-66), we like to have our body in a hundred sizes and a thousand variations. Body image changes continually and individuals triumph over the limitations of the body by adding masks and clothes to the body image. Owing to the fact that body image is the mental picture we have of our bodies, it has both perceptual and affective components, affects how we interact with clothes, and affects how that clothed appearance is presented publicly.

Apparel as the product of standard sizing is reflected in female evaluation of self and body, i.e. body cathexis. In a study by LaBat & DeLong (1990) that focused upon body cathexis and the perceptions of fit of clothing of 107 female consumers, responses indicated satisfaction with overall fit at lower body was less satisfying than at upper body

and total body. The body cathexis scores were slightly lower for lower body and lower body sites. Correlation for lower body fit satisfaction and lower body cathexis was statistically significant, confirming a relationship between the respondents' satisfaction with fit and feelings towards personal body (LaBat & DeLong, 1990:43-48).

Moreover, an Internet survey by Chattaraman and Rudd (2006) was administered to a random sample of 199 female undergraduate students. The results indicated that body image and body cathexis had a negative linear relationship with aesthetic preference in styling, implying that lower body image and body cathexis correlate with preference for greater body coverage through clothing and vice versa. Body size showed a positive linear association with styling preferences, implying that increase in body size correlates with preference for greater body coverage in clothing and vice versa (Chattaraman & Rudd, 2006:46-61).

A more recent study by Kim and Damhorst (2010), examined the relationships among body-related self-discrepancy, body dissatisfaction, apparel involvement, concerns with fit and size of garments, and purchase intentions based on self-discrepancy theory. A random sample of 348 college female students, drawn from a Mid-western university, indicated that consumers' perceived body-related self-discrepancy from online models had a direct relationship with body dissatisfaction. Consumers with higher enduring apparel involvement tended to feel a higher degree of body dissatisfaction (Kim & Damhorst, 2010:239-254).

Apparently, clothes can become a means of changing our body image, completely, while history tells us that from time to time, many attempts are made to change body image: tattooing, painting the lips, painting the face, bleaching, dyeing or dressing the hair changes the optic part of ourselves. When we wear different kinds of clothes or paint our body, we change the body image in an objective way. Understanding dress in everyday

life requires understanding not just how the body is represented within the fashion system and its discourses on dress, but also how the body is experienced and lived and the role dress plays in the presentation of the body/self. Entwistle (2000) believes that dress involves practical actions directed by the body upon the body, resulting in ways of being and ways of dressing, for example ways of walking to accommodate high heels, ways of breathing to accommodate a corset, ways of bending in a short skirt and so on. In this way, the analysis of dress enables us to see the operations of power in social spaces and how this power impacts upon the lived body and results in particular strategies on the part of individuals (Entwistle, 2000:39).

On the other hand, Calefato (2004:1-2) suggests that a garment exposes the body to a continuous transformation, while dressing has to do with feeling pleasure and with recognizing that such pleasure consists in transformation nature, in '*working*' it semiotically. Tate (2004) agrees that fashion is a term applied to the prevailing style at a given time, and as such, is in a constant state of change. '*Keeping up*' with fashion is, thus, important as a validation of one's awareness of these changes. Whatever piece of clothing we wear, immediately, becomes a part of the body image. Entwistle (2000:6-10) points out that dress in everyday life is always more than a shell, it is an intimate aspect of the experience and presentation of the self and is so closely linked to the identity that these three – dress, the body and the self – are not perceived separately but simultaneously, as a totality. Overall, Calefato (2004) states that clothes act as conveyors of meaning and value that give shape to a system of objects in which the body finds the space for innumerable and complex sensorial identities (Calefato, 2004:3).

One clearly discernible approach to the issue of meaning in fashion/dress has emerged from structuralism and semiotics and focuses particular attention on the role of fashion in

the construction of identity (Entwistle, 2000:66-67). In contemporary western culture class is no longer so readily apparent to the eye through dress alone but it is still the case that dress can mark out divisions between different groups, and this is particularly true in the case of youth subcultures. Subcultures use dress along with other popular cultural artefacts to mark out differences of taste, lifestyle and identity. However, if distinction is about setting oneself apart, it is also always about signaling to others that one is similar to them (Entwistle 2000:115). Modern books on social behaviour, whose topics range from flirting to management and business success, offer advice on how to 'read' the appearance of 'others' through their bodily appearance as well as how to control appearance to 'win friends and influence people'. Identity is therefore thought to be immanent in our appearance even while we are aware of the potential mistakes we can make when relying on surface information such as dress, body, hair, make-up and so on (Entwistle 2000:132-133). The clothes we choose to wear represent a compromise between the demands of the social world and our own individual desires. Finkelstein (1991:122) agrees that fashions are bonds that link individuals in a mutual act of conformity to social conventions. While fashion is important for defining styles at a given moment, these styles are always mediated by other social factors, such as class, gender, ethnicity, age, occupation, income and body shape. Roach-Higgins and Eicher (1992:1-8) pinpoint that development of a theoretical framework for understanding linkages between identity and dress depends on careful selection and definition of terms and development of a broad, holistic view of *Social Aspects of Dress*. Because dress functions as an effective means of communication during social interaction, it influences peoples' establishing identities of themselves and others. Identities communicated by dress are also influenced by technology and society-wide moral and aesthetic standards for dress. In addition, Calefato (2004:49) suggests that fashion often has to do with stereotypes, whether of an average notion of beauty, sexual gender or social roles.

Fashion as image and as a system conveyed through images (photography, film, television, Internet) is the place of imitation par excellence, the place where identity has strictly to do with repetition.

In a Kim *et al.* study (2002), the content analysis of 39 women's responses to open-ended interview questions revealed what impressions they formed of others based on appearance and dress, as well as what cues they chose, and the fact that they believed that others also used appearance and dress cues when forming impressions of them. Neither participants' impressions of others nor participants' beliefs regarding others' impressions of them contained information that extended beyond the perceived person to include other people or things associated with the perceived person. Instead, the content of the information inferred included personality characteristics, information about behaviours, biological traits, health and hygiene, and social roles. Most participants believed that both, they and others were accurate at decoding information from general appearance and dress cues, although some participants believed that accuracy was dependent upon the situation or related to specific appearance or dress cues (Kim *et al.*, 2002:125-137).

3.3. Representations of disabled females' bodies and The Role of Clothing

In Disability Studies, two discourses defining the disabled body are identified. The first is founded in modernist thinking and defined by the keyword *normality*. The second, founded in post-modern thinking is defined by the keyword *difference*. The case of '*Normality or Difference*' was a key-question for many theorists, such as Oliver (1990) and Stiker (1999), as well as for the feminist theory: In this perspective, the disabled woman is a deviation from the aesthetic norm: the female able body is identified as an object for desire and the disabled body as an object of disgust.

Living in a society of mostly able-bodied persons, individuals with disabilities / deformities often must contend with the effects of stigmatization - stigma refers to an attribute, either physical or psychological, that makes a person different from others, and therefore, less desirable. A comparison of his/her body appearance and functional capability with those of others, combined with the potential effects of stigmatization, may lead him or her to a negative body image, which also may affect his or her subjective well-being (Goffman, 1963:151-152). Based on such comparisons, one could speculate it would be difficult for an individual who has a deformity/disability to develop a positive attitude with respect to his or her body.

Many disabled persons find it hard to believe or accept that their disabilities can in many ways enhance their attractiveness. Some even angrily reject the idea. Moreover, to be *female* and *disabled* is considered today as *doubly monstrous* (Clarke, 2008:1-16).

The disabled woman in today's society fares worse than non-disabled women and disabled men. No doubt, disabled men, too, have to fight the stigmatized view of disabled people held by the non-disabled. Nonetheless, they are relatively advantaged in that they can observe and may aspire to the advantaged place of males in today's society (Fine & Asch, 1981:233-248). In contrast, women with disabilities are perceived as inadequate to fulfil, either the economically productive roles traditionally considered appropriate for males, or the nurturing, reproductive roles reserved for females (Broverman *et al.*, 1972:59-78; La France & Mayo, 1979:96-107). While we acknowledge that disability is costly in fact and in discrimination, for men and women, we argue that the latter bear the brunt of double discrimination. Disabled women (like racial or ethnic minority women) experience a major disadvantage in relation to their relevant 'single' minority reference groups: disabled men and non-disabled women. The disadvantage is

'double' because disabled women fare worse than both relevant comparison groups economically, socially and psychologically (Fine & Asch, 1981: 233-248).

Nevertheless, this condition of late modernity is not inevitable. It is not the only possible outcome of a digital and hyper-saturated image culture. The very tools, which have given rise to a narrowing aesthetic, could be redeployed to include the wide variety of bodies people actually have. In this way, there is a cultural potential for a heightened aesthetic appreciation of a wide range of body forms and anatomical variations (Hahn, 1988:26-31).

Disability is an obvious and powerful yet sophisticated symbol of being different, a difference that helps identify '*the other*' as being a potential partner to mate with and reproduce. Disability can be seen as a sexual symbol of '*the ultimate other*', while the sexual feelings triggered by atypical physiques have exerted consistent and disturbing effects on the social and political perceptions of the non-disabled majority (Hahn, 1988:26-31). As validity is reduced to appearance, and physical beauty and fitness become key symbols of cultural capital, it seems likely that, for impaired people, the exclusionary practices of old will take on new forms. Aesthetic forms of oppression and the struggle against them will be intensified, while new ways of struggling against the cultural production of marginalization are required, when pride and difference seem to be the concepts / practices that are emerging to serve this end (Hughes, 1999:155-172). Given that the female body is also perceived as a possibility for change (Morgan, 1991), female bodies could be an arena for transportation, parody and protest and that one possible strategy would be to destabilise the beautiful by demanding ugliness: the able-bodied woman suggesting ugliness is in a different situation to the disabled/deformed woman, but the deformed body is also a possible arena for destabilizing the beautiful. Ugliness has always held its own fascination, its own kind of splendour (Morgan, 1991:25-53).

Hence, it is not necessarily in the long-term interests of the style-industries to promote a limited aesthetic. Indeed, it may benefit these same industries to celebrate diversity and variety and to make it their ethical aim to transform the body distress so many experience today (Orbach, 2009:12). This will imply a rejection of conformist visions of beauty, and a provision of greater possibilities for appreciation of the disabled body (Hahn, 1988:26-31).

It is, therefore, easy to understand why a person's positive or negative feelings towards his or her body image may very well affect his or her psychosocial well-being (Goffman, 1963). This process hopefully results in some sort of resolution and acceptance of the disability and a willingness to rebuild a sense of self and self-esteem. It is then that the wish to look '*normal*' surfaces. Once individuals who experience a disability or a body deformation, due to illness, start exhibiting a concern about clothing and appearance, it is assumed that they are well on the road to psychological recovery. This concern for looking '*normal*' and being socially acceptable is a milestone in the recovery process (Chase & Quinn, 2003:3-4).

As spinal injury can cause paralysis (WHO, 2002:17) for certain impaired or disabled individuals, the attractiveness of clothing could be very important, while a good fit could enhance the psychological and physical comfort, which is crucial for their self-esteem and positive self-image. Others should not be immediately aware of the disability, but should see a well-dressed person and maybe after that, the deformity, or disfigurement (Hoffman, 1979). The disabled individual can feel embarrassment and shyness because of defects of self-image caused by body disfigurement or disability. This can lead the individual to avoid participation in social activities (WHO, 1980). It is a psychological need to feel attractive and not set apart from the group, by the clothes one wears (Hallenbeck, 1966:34-40). Impaired or disabled women, who require functional clothing,

need to show that their identity is more than just their disability and as such, fashion provides an outward expression of that identity. Wearing fashionable clothing can also compensate for perceived physical deficiency due to disability, and to disguise or conceal a disability (Wingate et al., 1986:37-47). It is very important that an impaired or disabled woman is free to choose clothes according to her own style and through that, establish various personal priorities (The Disabled Living Foundation, 1994).

Hence, individuals with divergent body figures or large disfigurements should be able to find well-fitting and aesthetically pleasing clothing, while designers should try to develop their pattern design methods, constantly (Hernandez, 2000:92).

3.4. Questionnaire Design and Purpose

For a deeper understanding of the culture and the needs of young females with scoliosis of the spine, 75 females aged 16-22, diagnosed with AIS, were asked to complete a 25-question questionnaire, after each one of them had been measured in a hospital setting (from 16/12/2008 to 12/6/2012), in order to collect demographic and psychographic data, relative to retail clothing and fit issues. Participants were divided in three different curve-size groupings related to scoliosis (mild - moderate – severe, see Chapter 2.5:40), which were formed in order to examine whether different curve-size groupings exhibited similar characteristics that were relative to body cathexis, clothing benefits sought, and fit problems and preferences.

Using these groupings, coupled with fit preference information, the process of the later pattern development, involved shaping a two-dimensional fabric to fit a three-dimensional body shape, using darts and ease, in order to adjust the flat surface of fabric to the curvature of a body shape. Close-fitting basic pattern blocks were, thus, developed for the two most populated scoliotic groups, according to each group's median

measurements, while each subject's individual fit preferences often determined whether the specific subject would evaluate a garment as a good fit or not. Therefore, fit preferences and problems identified for each group could be then used in determining the amount of ease that should be used beyond basic body measurements to satisfy fit requirements.

The preliminary research focused on a concise questionnaire (Appendix A1), in order to establish the nature of adolescent females' with scoliosis relationships with their body image, in relation to conventional retail clothing, fashion, and with their bodies, in general; the questionnaire consisted of a consumer survey supplemented with one-to-one informal interviews during the filling out and a market analysis on apparel fit and branded clothing preferences.

A way to assess body (dis)satisfaction is to ask women to complete self-report questionnaires, while body satisfaction questionnaires are designed to provide a quantitative measure of body satisfaction. Most ask respondents to indicate the degree of agreement or disagreement with statements relating to satisfaction with particular body parts (Body Cathexis) or with the body as a whole (Grogan, 2008:45). Assessment of body image in scoliosis patients has been limited to written questions about perceptions of attractiveness in clothing or bathing suits, satisfaction with the body or with the physical appearance of their rear view, and psychosocial distress as a result of deformity or brace wear (Danielsson et al., 2001:278-288). However, as Donaldson et al. (2007:1526-1532) point out, few attempts have been made to qualify which aspects of deformity are the most distressing for patients. Such information would be useful for clinical decisions, such as whether or not to perform thoracoplasty¹¹ in addition to spinal fusion, or whether to recommend conservatively treated patients for surgery. The most

¹¹ Reparative or plastic surgery performed on the thorax. In:

concentrated effort in this area was the development of a visual analogue scale to quantify patient self-assessment of deformity by Sanders *et al.* (2003:2158-2163). Known as the '*Walter Reed Visual Assessment Scale*' (WRVAS), this scale was designed to allow idiopathic scoliosis patients to describe their perception of their deformity without cognitive or emotional connotations, and featured seven items which addressed visual aspects of scoliosis, including: body curve, head pelvis, rib prominence, shoulder level, flank prominence, scapula rotation and head rib pelvis. Thus, the WRVAS is considered to be a more accurate reflection of the impact of scoliosis deformity on patient body image and HRQL (Health Related Quality of Life) than radiographic indicators (Sanders *et al.*, 2003:2158-2163).

For this research, it was envisaged that a two-paged questionnaire with a series of 25, mostly open-ended, questions would be the most appropriate in order to obtain an idea of the types of issues that concerned the specific target group. All questions were formulated in a manner that made the respondents describe and reflect on their experiences with their bodies in relation to clothing, in the form of a conversation, looking for comprehensive descriptions and experiences from participants who have met challenges when shopping for clothes, while the intention was to interview these adolescent girls with atypical body types, which may constitute an additional challenge. All survey data are presented in Excel (Appendix A) – each subject represented by a different Excel sheet, with a heading on each sheet that gives information about the respondent: *Subject No, Curve Size, Date* on which the survey was filled out and *Name*, e.g.:

SUBJECT 75 (Curve Size 3) (12/06/2012)

NAME: *MARILYN MONROE*

<http://medical-dictionary.thefreedictionary.com/thoracoplasty> (Accessed 1st February 2011)

Overall, the participants in this project completed a *Participant Consent Form* and a two-paged, 25-question survey (Appendices A1 - A), including questions regarding perception of their body image in relation to conventional retail clothing, which aimed to express the inner ambitions, desires and fears of girls with AIS. The survey was complemented with informal interviews, market analysis on brands and garment fit. It was really interesting to find that 72% of the girls interviewed ($n=57$ out of 75: whole sample), described their scoliosis as a physical condition having no impact at all on their outward appearance, while 84% stated that they were totally happy about the way they looked when wearing conventional retail clothing. Nearly the whole sample (93.33%) claimed that they had never needed to alter any retail garment due to their scoliosis, nevertheless, 41.33% stated that they had often worn clothes made especially for them. Moreover, 85.33% didn't think that their scoliosis prevented them from following fashion trends as they wished, while 44.44% of the girls classified as '*Curve Size 3*' (severe spinal deformity: $n=4$ out of 9), claimed that they had been avoiding wearing close-fitting clothing - especially tops or coats, a fact indicating that high shares of the consumers who have a body out of touch with the existing beauty ideals express discontentment with the sizing systems and the poor selection available. Consumers tend to blame themselves when the clothes do not fit their bodies, while this study points out that the industry is to blame as they do not produce clothing for all the customers.

In the beginning, the response of the girls was quite restrained, which lead to the conclusion that the questionnaire either bored them, or was designed in such a way that made them reluctant to talk about their deepest feelings, claiming that their scoliosis didn't affect them at all – while, at the same time, their mothers complained that their daughters' scoliosis made them very sensitive, nervous and always frustrated – when it came to buying clothes. Certain answers to questions 3,5,10,11,21,24 and 25 (see the

questionnaire, Appendices A1 and A – Participants' Responses), however, showed that girls' with scoliosis experience of going shopping for clothes was a major area of concern for them.

This contradiction between mothers' and daughters' opinions lead to the researcher's decision to apply an auto-ethnographic approach for this study. Thus, in order to utilize the experience of all the girls who expressed an interest in the research, the questionnaire was accompanied by a small face-to-face (informal) interview in the form of conversation, during which the researcher mentioned to the girls that she had had scoliosis, herself. Hence, the researcher related to them by asking questions from the survey and taking notes on their responses, while those girls who were not interested in filling in the questionnaire were offered the opportunity to take part in a 'guided' conversation, or receive support to fill it in.

Overall, the questionnaire was designed to have mostly qualitative information derived from it. The primary aim was to explore the experiences of girls with AIS, in relation to clothing, rather than investigate the characteristics and drawbacks of scoliosis, including open-ended questions about their current and previous experiences in clothing selection, and about how, under certain circumstances, conventional retail clothing might not be appropriate for them.

To conclude, as pointed out by various researchers and authors, such as Entwistle, Shilling and Turner, it was found that both qualitative interviews and commentaries in the questionnaire showed that the relationship between bodies and clothes is not strictly a question of body type or a size code but involves deeper individual and social questions (Entwistle, 2000:7-12; Shilling, 2004:87; Turner, 2004:82).

3.5. The Psychological Impact of Clothing on Body Image of Girls with AIS, viewed through the researcher's perspective due to personal experience of living with scoliosis

Unfortunately, as mentioned earlier (pp. 58), there are certain adolescents with severe spinal curvature due to scoliosis (44.44% of the girls with severe spinal deformity: $n=4$ out of 9) that cannot select their clothes, according to their desire, and experience huge difficulties in finding clothing suitable to fit into or possible to alter. It is mostly important for them to find clothes according to their desires, the function of which is of secondary importance. Social integration and acceptance are established for these individuals when they wear or have adapted garments that conform to their unique body figures. Although adolescents with mild scoliosis usually continue to go to school, the consequences of their physical deformation can interfere with their daily lives, measuring or examining the 'flawed' spine repeatedly, or spending large sums of money and amounts of time on clothing, in order to 'hide' their deformity. Adolescents with severe deformities may even refuse to go to school or leave their homes, while many young girls with scoliosis seek the help of a surgeon to try to correct their spinal deformity.

Outcomes from psychosocial and HRQL (Health-Related Quality of Life) studies indicate that body image is a complex and significant issue for patients with scoliosis and their clinicians (Tones et al., 2006:3027-3039). According to the 'body image' literature (Tones & Moss, 2007:2:14), medical conditions threaten the stability of patient body image via changes to bodily sensation, functioning and appearance (Pruzinsky, 2004:71-81). In particular, disfigurement or deformity can promote a negative self-image within the individual, who may also experience difficulties with social interaction due to potential adverse reactions from others as a result of the visibility of their condition (Rumsey & Harcourt, 2004:83-97). As scoliosis is rarely life-threatening, the clinician's decision to

perform scoliosis surgery on adolescents hinges on current and prospective spinal deformity, with patient HRQL and surgical considerations performing auxiliary roles in the decision making process (Donaldson *et al.*, 2007:1526-1532). Cosmetic issues and physical symptoms are the key indicators for scoliosis surgery in adult patients, even though further curvature progression is extremely unlikely (Asher & Burton, 2006:1:2). However, clinical assessments of scoliosis correlate poorly with patient self-perceptions of deformity and self reported HRQL (Buchanan *et al.*, 2003:2700-2705). Assessment of body image and factors likely to influence body image (HRQL) is important for scoliosis patients, as difficulties in these areas may have an adverse affect on treatment compliance and satisfaction in adolescence, and limit psychosocial functioning in adult life (Orvomaa, 1998:169-178). For adolescent patients treated conservatively, brace wear exerts a greater impact on body image and HRQL than the deformity itself (Kotwicki *et al.*, 2007:2:1). Correlations between radiographic measures and self reported out-come measures range from mild to moderate amongst adolescent surgical candidates, with a tendency for stronger correlations in the Self Image, Function and Pain domains HRQL, and poorer outcomes amongst patients with thoracic curvatures (Asher *et al.*, 2003:74-77).

The psychological impact of clothing has been the topic of many books and research projects, while clothing's positive effect on self-esteem, productivity and performance has been strongly and clearly established. Chase & Quinn (2003) state that studies have shown that disabled children are more clothes-conscious than able-bodied children, while other research has indicated that in a rehabilitation setting there is a significant rise in the self-esteem of patients, after fashionable, functional clothing is developed for them. According to a therapist at Moss Rehabilitation Centre, many patients feel that ill-

fitting, constricting clothing is just part of the suffering that they must endure as disabled people (Chase & Quinn, 2003:3-4).

In the Department of Clothing and Textiles, Virginia Polytechnic Institute and State University, in Blacksburg, Liskey-Fitzwater *et al.* (1993) explored clothing importance and self-perception of female adolescents with and without scoliosis on sample groups of 35 female adolescents with scoliosis and 35 peers without scoliosis. The sample groups were studied for two purposes: firstly, to investigate differences in selected clothing importance factors and self-perception domains between the two groups; secondly, to investigate the relationship between clothing importance and self-perception within and between groups. After the data analysis, it was found that the scoliosis sample had significantly lower scores on clothing to enhance self-concept than did their peers, while significant differences were found between groups on all self-perception variables with the scoliosis sample having the lower scores (Liskey-Fitzwater *et al.*, 1993:16-22).

The majority of subjects in this particular research's scoliotic sample presented a mild spinal curvature (67.56%, $n=50$), while subjects with a moderate or a severe spinal curvature represented 20.27% ($n=15$) and 12.16% ($n=9$) of the sample, respectively (Table 2.3, p.25).

The following findings, interpreted based on the researcher's personal experience of living with scoliosis, show that individuals with mild scoliosis (10-34 degrees) and/or certain individuals with moderate scoliosis (35-54 degrees), usually, do not face serious problems in fitting in retail clothing, while those with severe scoliosis (over 60 degrees) are bound to have difficulty in terms of fitting into symmetrical retail clothing.

3.5.1. Findings on the psychological impact of clothing on Body Image of girls with AIS in Greece

Over two thirds of the girls participating in this study (72%, n=53) – 22% (n=2) of the girls with severe deformity, two thirds of the girls with moderate deformity (67%, n=10) and 82% (n=41) of the girls with mild deformity – described their spinal deformity as a physical condition having no impact at all on their outward appearance. This ratio seems perfectly justified, given the visual outcome of the deformity (Table 3.1).

On the one hand, 88% of the whole sample – 88% of subjects with mild deformity, 93% of subjects with moderate deformity and 78% of subjects with severe deformity – claimed that people, usually, do not make any comments on their scoliosis (Table 3.2).

On the other hand, 85% of the whole sample – 84% of subjects with mild deformity, 80% of subjects with moderate deformity and 100% of subjects with severe deformity – claimed that they didn't really care about what other people thought regarding their scoliosis (Table 3.3).

At this point, it is very interesting to note that, in this study, adolescent girls with moderate deformities were found to care more about other people's opinion on their scoliosis, than those with mild deformities, while those with severe deformities were found not to care at all about other people's opinion on their scoliosis.

Having experienced the condition of scoliosis, herself (at the age of 14 years), the researcher, however, would expect that the girls with severe deformity ('Curve Size 3' subjects) would care even more about other people's opinion, than the other two groups, given the visual outcome of the deformity due to the prominent curvature.

Table 3.1

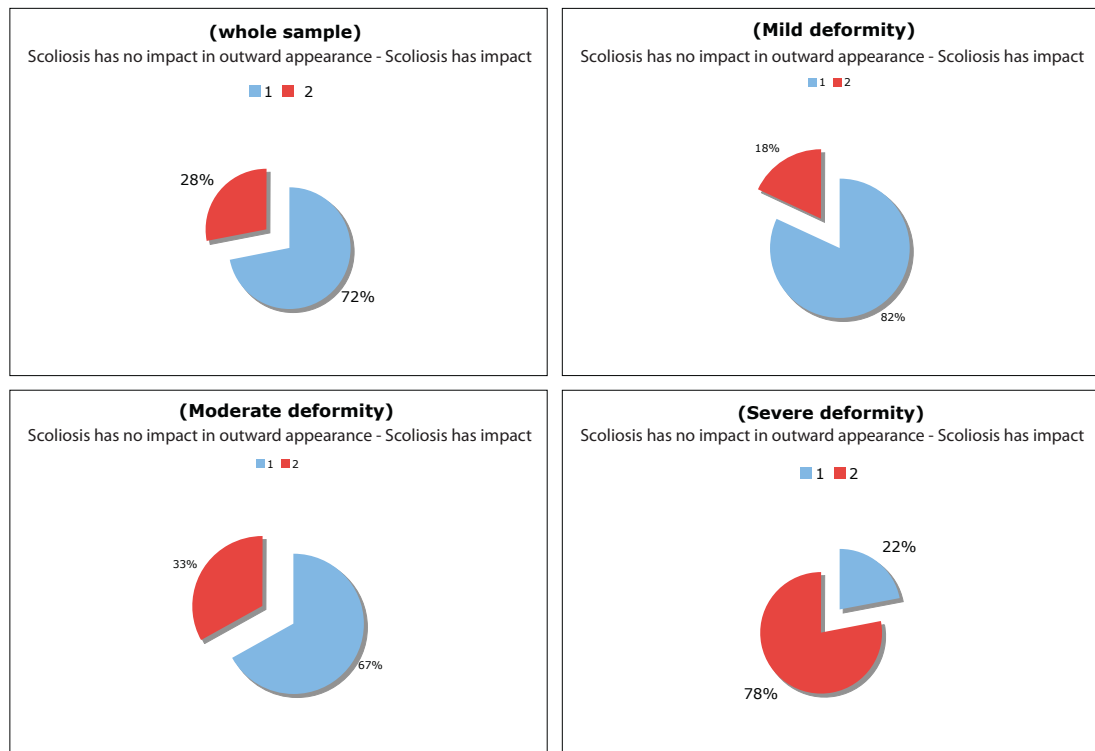


Table 3.2

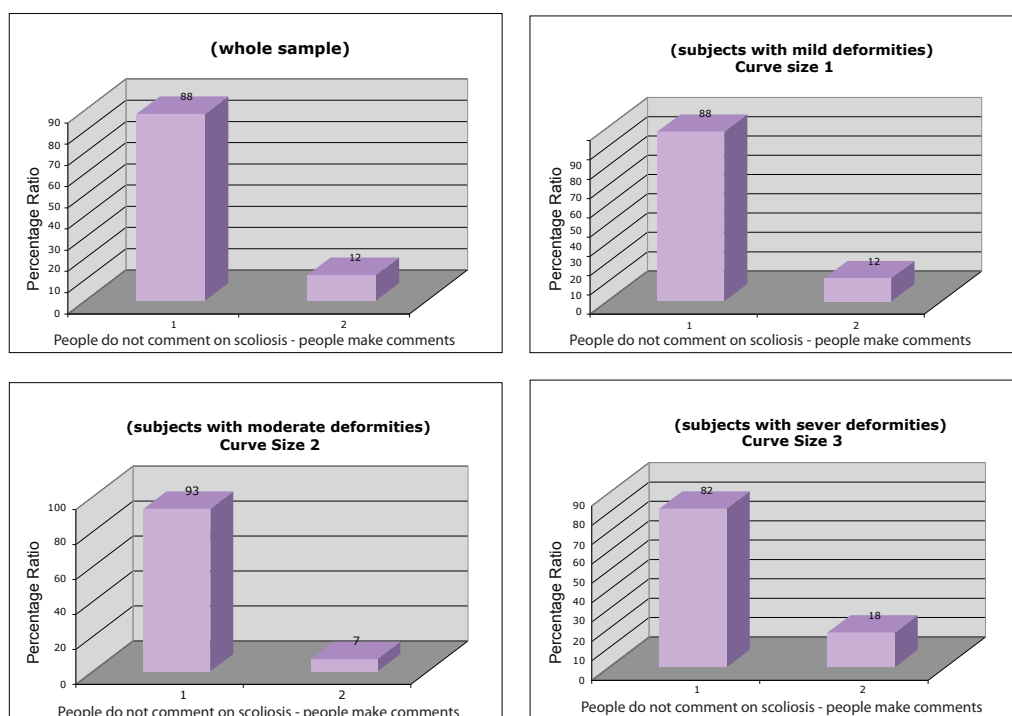
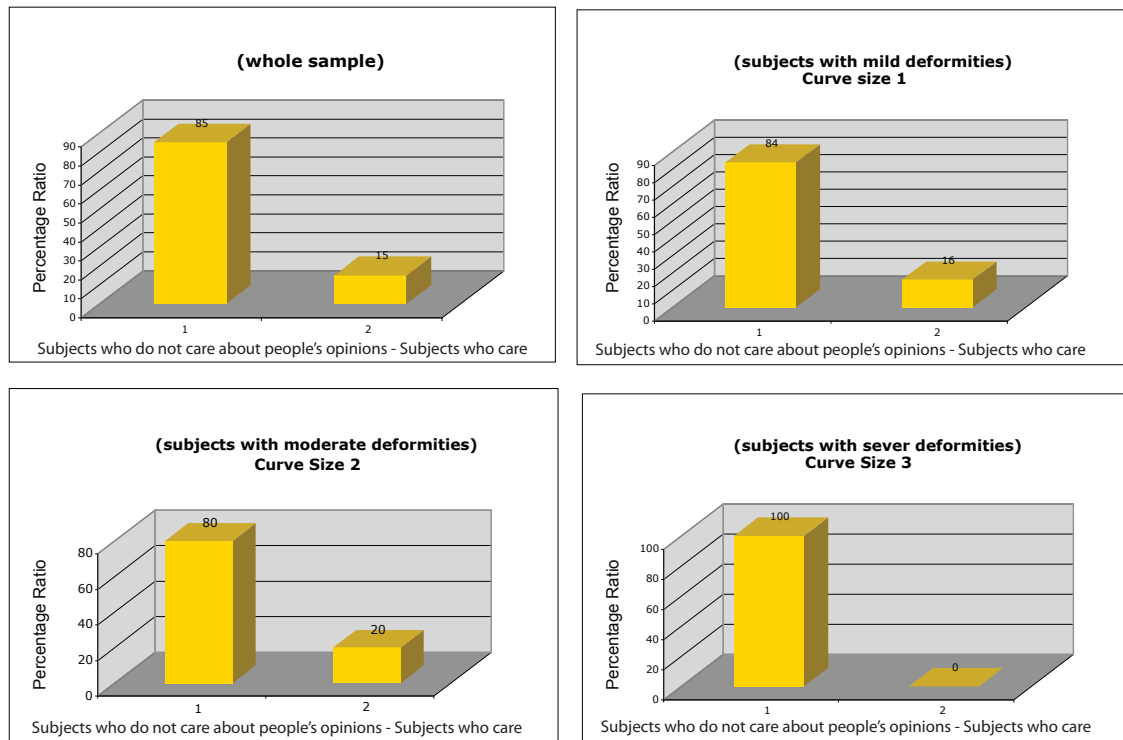
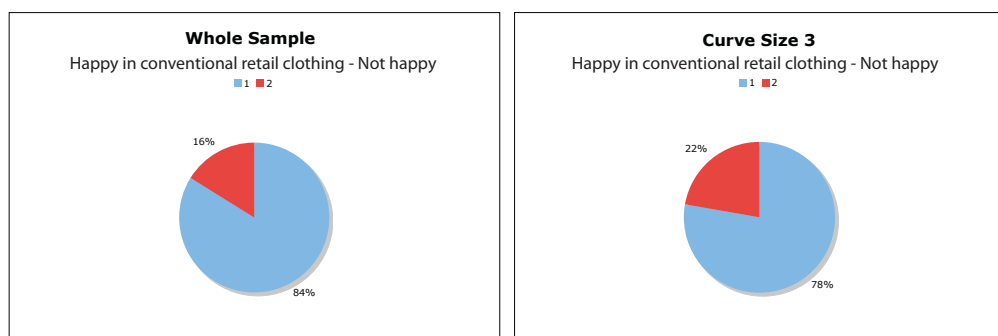


Table 3.3



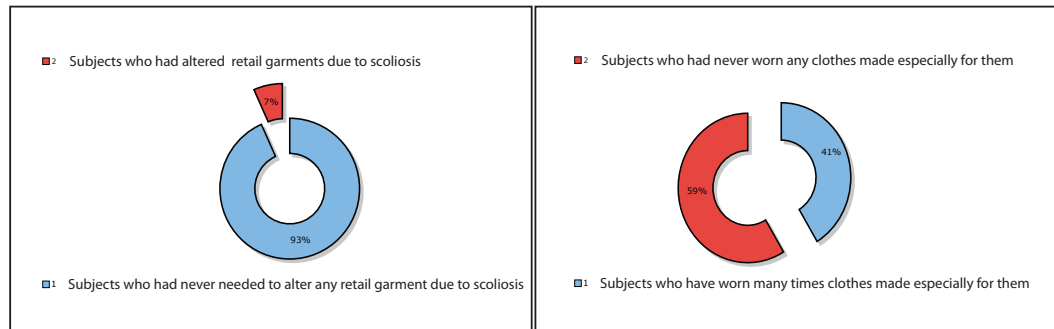
Moreover, 84% of the subjects filling in the questionnaire (Appendix A) - 84.31% of girls with mild spinal curvature, 86.7% of girls with moderate spinal curvature and 77.8% of girls with severe spinal curvature - stated that they were totally happy about the way they looked when wearing conventional retail clothing (Table 3.4).

Table 3.4



Notwithstanding, nearly the whole sample (n=69) claimed that they had never needed to alter any retail garment due to their scoliosis, when just less than half of the girls (n=31) stated that they had often worn clothes made especially for them (Table 3.5).

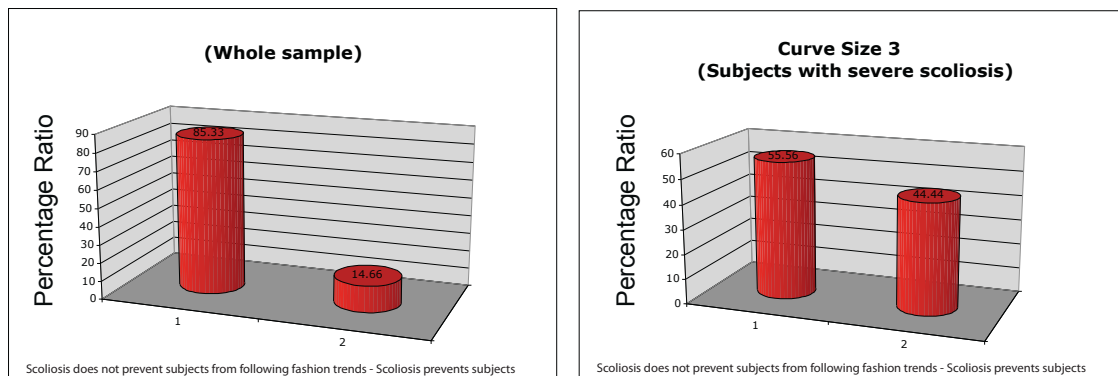
Table 3.5



According to the researcher's personal perspective, the above contradictory responses (Table 3.5, p.65) indicate that it is possible that certain girls were 'putting on a brave face' in order to hide their deepest feelings related to their condition and give - what they thought would be - an '*acceptable*' answer, appearing as their peers and not being set apart from the group.

It is also worth mentioning that the majority of the girls (85.33%, n=63) didn't think that their scoliosis prevented them from following fashion trends as they wished, while nearly half of the girls with severe spinal deformity (44.44%, n=4) claimed that they had been avoiding wearing close-fitting clothing, especially tops or coats (Table 3.6). These findings, however, seem perfectly justified, given the visual outcome of the deformity.

Table 3.6

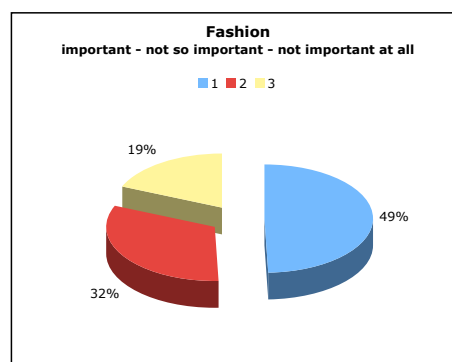


Apparently, on a physical level, living with scoliosis can be a very complex process; on a psychological level it can become an even greater struggle. If a large part of 'normalcy' hinges upon positive self-esteem, and clothing can help to provide that self-esteem, then great energy and support should be provided to make appropriate clothing available.

3.5.2. Findings on the impact of Fashion and Clothing preferences of girls with AIS in Greece

Nearly half of the sample (49.33%) claimed that fashion was quite important for them, while one-third (32%) claimed that they followed fashion trends as much as they could, and the remainder 18.66% stated that they didn't care about fashion at all (Table 3.7).

Table 3.7



Bright and radiant colours seemed to be teenage girls' favourites of all three different curve sizes: 67.6% said that they preferred to wear bright colours - white (33.33%), blue (28%), red (22.66%), green (21.33%) and fuchsia or pink (18.66%) - to dark colours - purple (20%), brown (13.33%), grey (17.33%), or other colours, like khaki, orange, yellow and burgundy (29.33%).

On the contrary, more than half of the sample (54.66%), despite the severity of their spinal curvature, stated that black colour was the dominating colour in their wardrobe (Tables 3.8 & 3.9).

Table 3.8

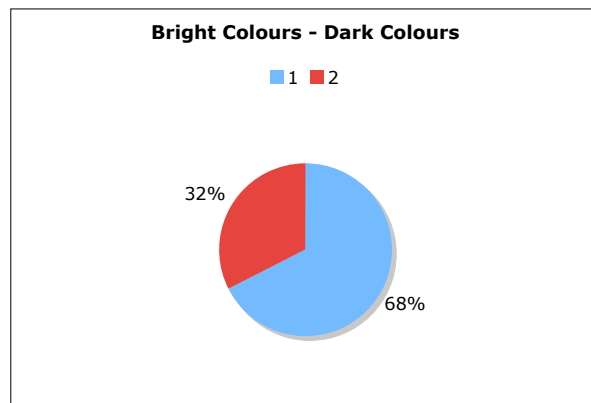
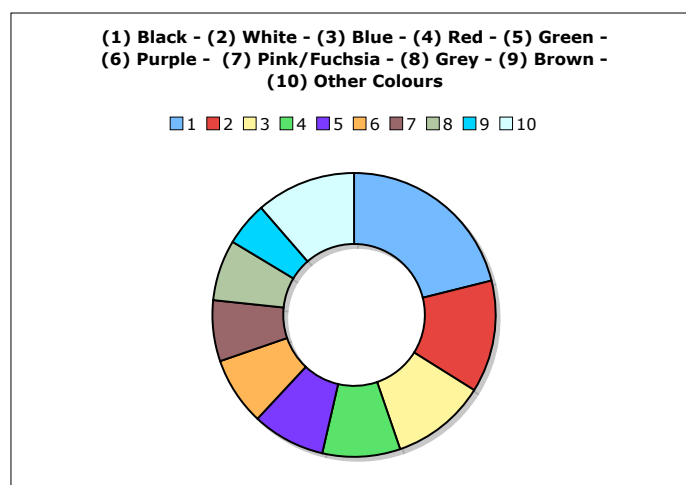
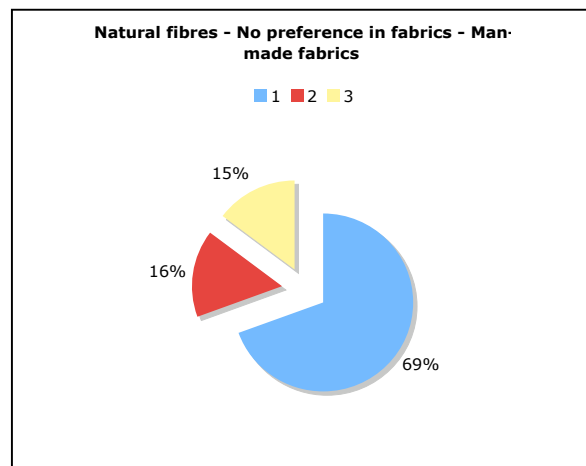


Table 3.9



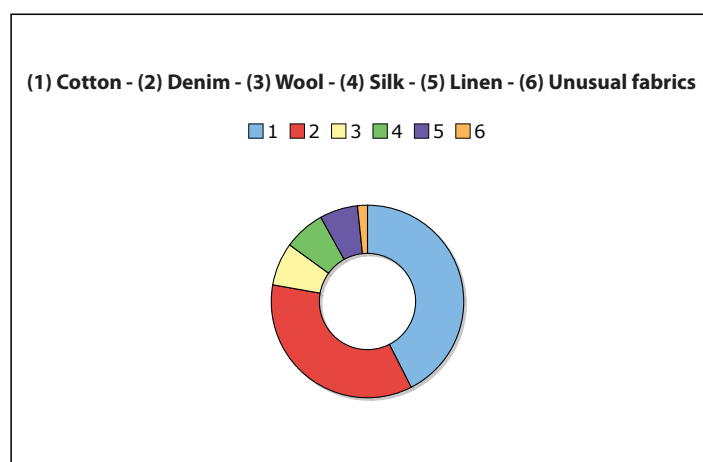
The girls that preferred natural fibres (69.33%) outnumbered those that didn't care about fabrics (16%), or would easily wear man-made fabrics, such as viscose or Lurex, and glossy fabrics (14.67%) (Table 3.10).

Table 3.10



Cotton fabrics were on top of the list of preferences (64%), while more than half of the girls (53.33%) liked denim, as well. Wool and silk were preferred, each by 10.66% of the subjects, whereas linen by 9.33%. The girls who preferred to wear unusual fabrics represented only 2.66% of the whole sample (Table 3.11).

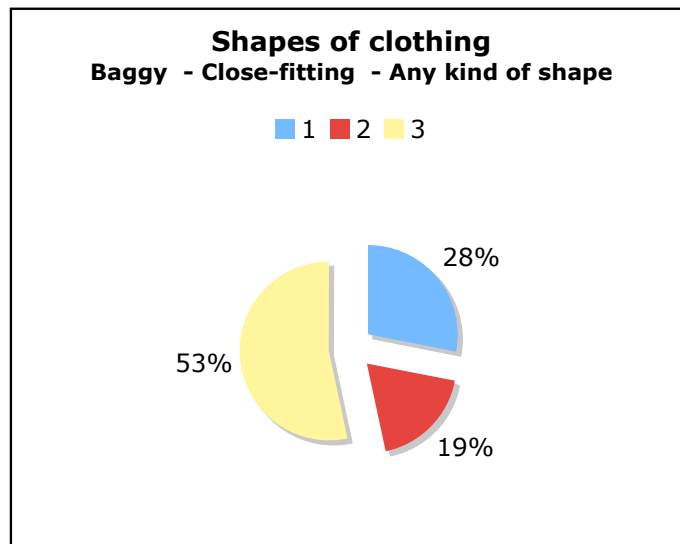
Table 3.11



In terms of shapes of clothing, approximately one third (28%) felt more comfortable in baggy clothes, nearly one fifth (18.66%) preferred close-fitting clothes, whereas the remainder half (53.33%) wouldn't mind wearing any kind or shape of clothing (Table 3.12).

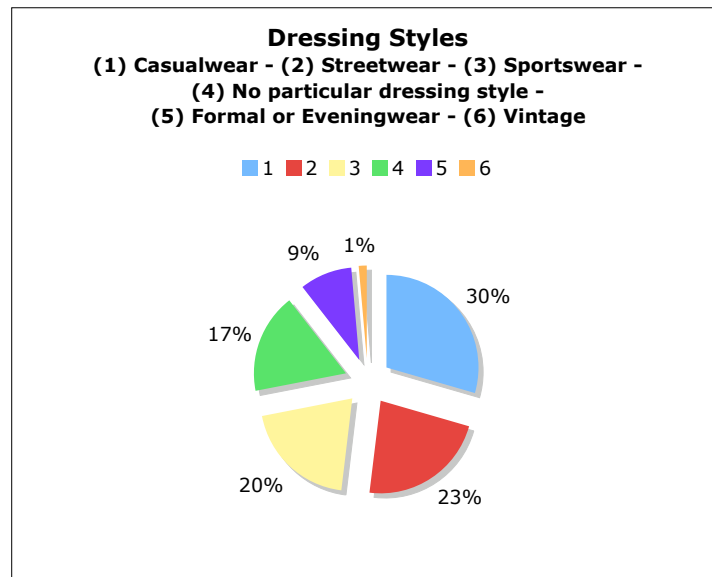
According to the researcher's personal experience of living with scoliosis, subjects' preference (28%) in baggy clothing could subconsciously indicate a deeper need of those certain subjects to 'hide' the deformity, by accommodating the prominent curvature inside clothing that are loose around the body, creating thus, an illusion of symmetry.

Table 3.12



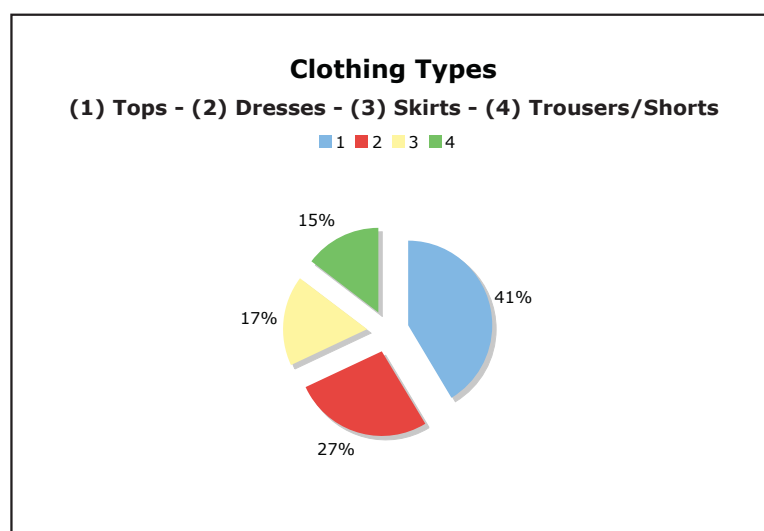
In terms of dressing styles, almost one third of the whole sample (29.33%) preferred to buy casual clothing, less than one quarter (22.66%) were keen on street-wear, exactly one fifth (20%) on sportswear and less than one fifth (17.33%) wouldn't care about styles of clothes. Only 9.34% of the whole sample favoured formal-style clothing or eveningwear, while one girl stated that she would wear only vintage clothing that she would customise herself (Table 3.13).

Table 3.13



In terms of clothing types, less than half of the sample (41.33%) would go shopping for nice and unusual tops or trendy T-shirts. Over one quarter (26.66%) would buy only dresses, mini dresses or long tunics to combine with skinny jeans or leggings, while 17.33% would buy skirts and 14.66% shorts or trousers (Table 3.14).

Table 3.14

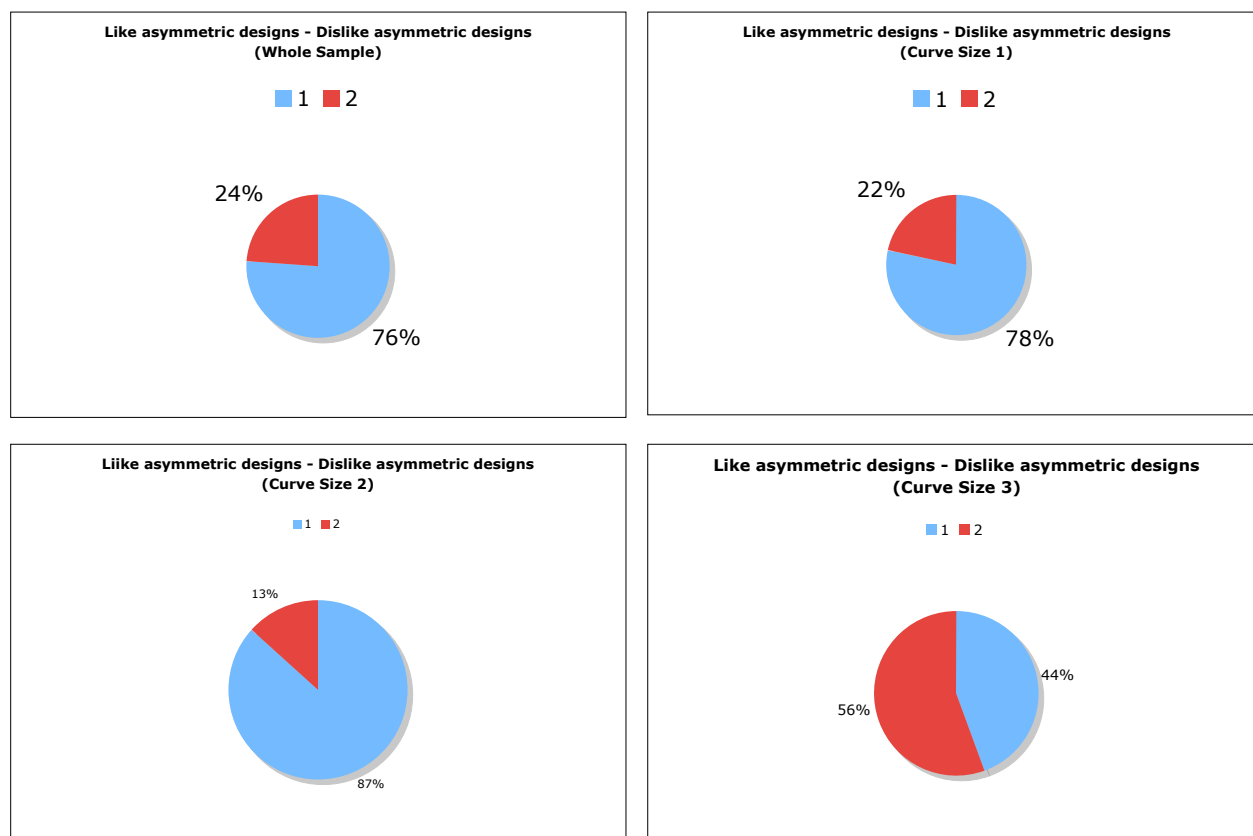


Formal, classic-style clothing and eveningwear were preferred only by girls with mild spinal curvature, while none of the girls with severe deformities expressed preference for dresses or tunics. Concurrently, over one third of the sample would buy mostly conventional jeans (38.66%) or skinny jeans and leggings (36%).

Most of the girls (76%) stated that they had worn, at least once, some kind of asymmetric-design clothing. It is quite interesting to note, here, that the highest percentage of those girls belonged to the group of girls with moderate deformities (86.66%). Girls who had worn, at least once, some kind of asymmetric-design clothing, represented 78.44% of the girls with mild deformities, while girls who had worn, at least once, some kind of asymmetric-design clothing, represented only 44.45% of the girls with severe deformation, when one would expect them to have the highest percentage, compared to the other two groups, due to their more obvious body asymmetry and expected physical tendency to be more familiar with asymmetric designs.

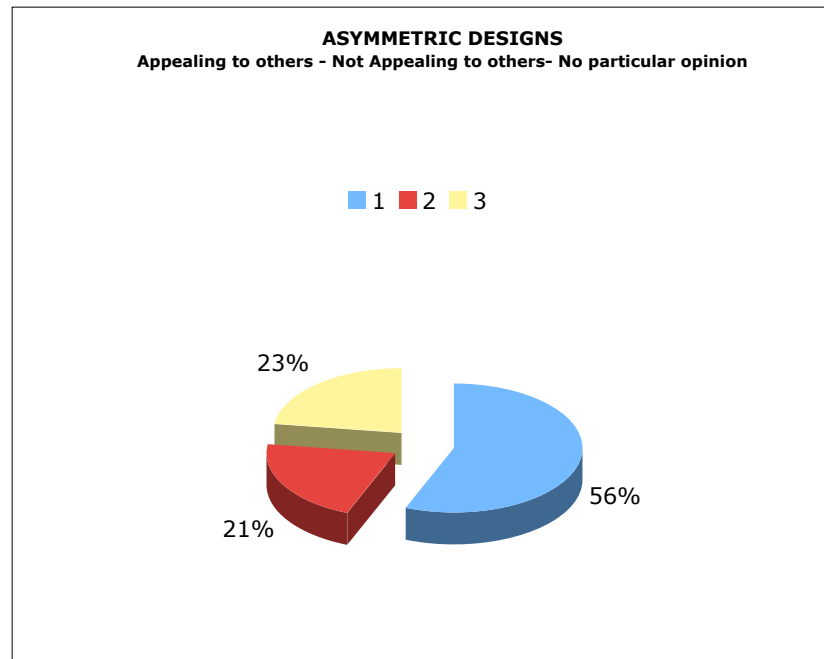
On the contrary, more than half of the girls with severe deformities (56% of Curve Size 3 girls, $n=5$ out of 9) expressed dislike for asymmetric clothing designs, this percentage being the highest, compared to the other two groups, i.e. girls with mild and moderate deformities, who also didn't like asymmetric clothing designs (22% of Curve Size 1 girls, $n=11$ out of 50 and 13% of Curve Size 2 girls, $n=2$ out of 15, respectively) (Table 3.15).

Table 3.15



Furthermore, 56% of the whole sample believed that asymmetric-design clothing were appealing to other people, in general, whereas the rest of the sample had no opinion on whether this type of clothing were appealing to other people (22.67%), or believed that other people, in general, do not like asymmetric-design clothing (21.33%) (Table 3.16).

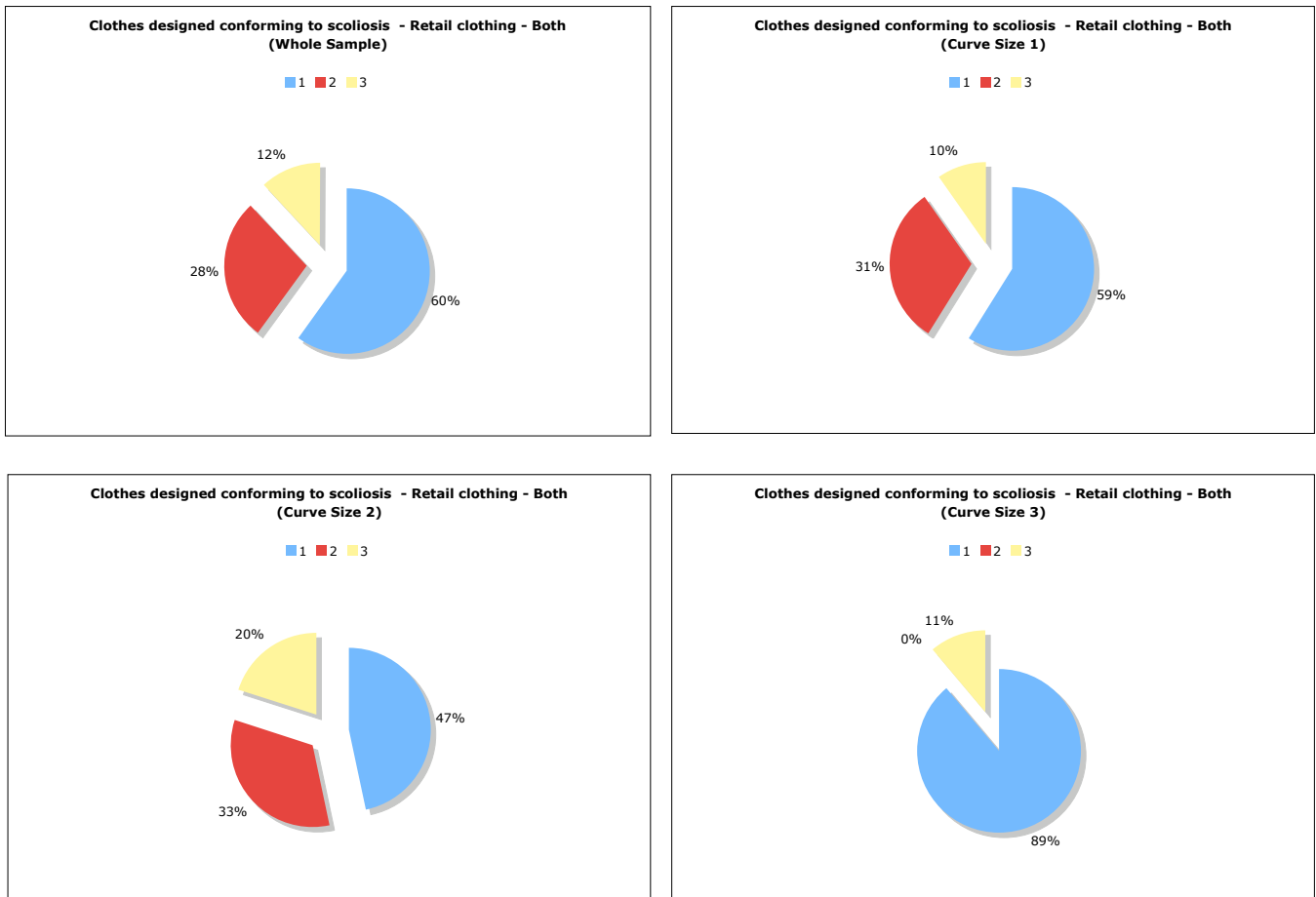
Table 3.16



Generally, the participants who would rather wear clothes designed conforming to their scoliosis (60%) were twice as many than those who would rather wear (customized or not) retail clothing (28%), and five times as many than those who wouldn't mind wearing any of the above (12%). At this point, it is interesting to note that none of the girls with severe deformation (Curve Size 3) would prefer to wear (customized or not) retail clothing (Table 3.17).

To conclude, almost all adolescent girls participating in this questionnaire (94.66%) thought that there is certainly a great need for pattern design to comply with non-standard body sizes due to distinctive spinal features, as their scoliosis.

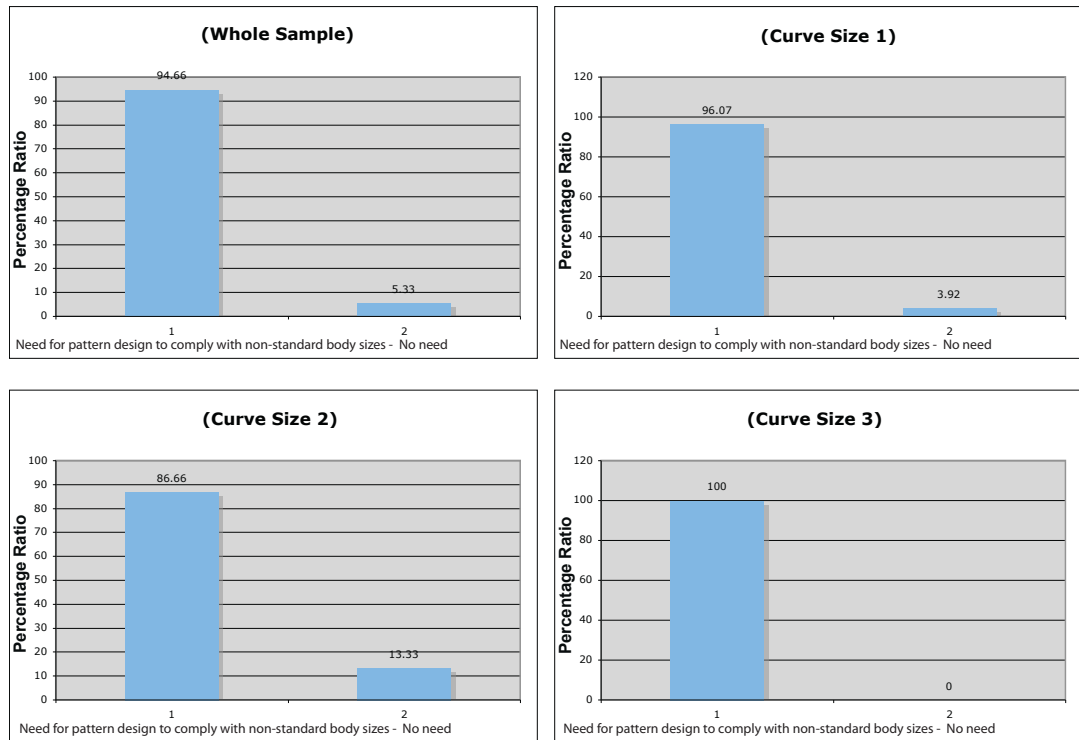
Table 3.17



More specifically, girls with mild spinal deformities, who believed that there is a need for pattern design for clothing or fashion products to comply with non-standard body shapes and sizes due to scoliosis, were represented by 96.07%, girls with moderate deformities by 86.66% and girls with severe deformities represented by 100% (Table 3.18).

The above findings are contradictory with the fact that 84% of the subjects had stated that they were totally happy about the way they looked when wearing conventional retail clothing (Table 3.4), which implicates, once more, according to the researcher's personal perspective, that certain subjects might have been 'putting on a brave face' when filling out the questionnaire.

Table 3.18



3.6. The Role of the Media in Shaping Body Image and Self-Esteem of Adolescent Girls

In today's culture there is a lot of emphasis placed on body weight, size, and appearance, while the social costs of this approach are beginning to be recognized. Beauty begins to matter in the nursery and continues to matter through old age. Adolescents' physical characteristics provide a basis of their own body image and psychosocial development by either fulfilling or not fulfilling the stereotypical images of their social milieu, and as they may compare themselves with the people around them or with media images and body ideals of actors and celebrities they see on TV, in movies, or in magazines, it's little wonder that women (and men) feel inadequate, ashamed, and

dissatisfied with how they look. The constant barrage of unrealistic images influences the concepts of body value.

A longitudinal study by Hargreaves & Tiggemann (2004) aimed to examine the effect of exposure to images of idealized beauty in the media, on adolescent girls' and boys' body image. The participants (595 adolescents) viewed television commercials containing either images of the thin ideal for women, images of the muscular ideal for men, or non-appearance television commercials. Body dissatisfaction was measured before and after commercial viewing and it was found that exposure to idealized commercials led to increased body dissatisfaction for girls but not for boys. Idealized commercials led to increased negative mood and appearance comparison for girls and boys, although the effect on appearance comparison was stronger for girls. The results suggest the immediate impact of the media on body image is both stronger and more normative for girls than for boys, but that some boys may also be affected (Hargreaves & Tiggemann, 2004:351-361).

Moreover, Jung (2006:335-344) measured twice, with an interval of 4 weeks, the mood and body image of 106 college women, divided into two groups (high - vs. low-appearance self-schema). Generally, there weren't any significant effects of exposure to media images noticed in women's body image scores, however, exposure to media images had an influence on women's mood by decreasing positive mood and elevating anxiety and depression from pre-exposure to post-exposure. In both pre- and post-exposure conditions, women with high-appearance self-schema exhibited significantly greater negative mood and lower body dissatisfaction and appearance evaluation than did those with low-appearance self-schema. This study suggests that media images of thinness and attractiveness may negatively affect college women's mood.

Apparently, the concept of the '*ideal body*' constructed by the media, in order to sell products, which are related to the insecurity and unhappiness that it generates, has certain restrictions on the thoughts and feelings of women, which are profoundly anti-women's freedom.

However, there are ways of resisting media pressure by rejecting traditional images of the body and replacing them with a revolutionary new aesthetic of the body that perceives the 'natural' range of body types to be acceptable (Bartky, 1990). History discloses abundant proof that images of beauty have changed continually and that physical differences or disabilities sometimes have been considered attractive and appealing.

In the February 1995 edition of American '*Vogue*', Helmut Newton, the decadent fashion photographer, explored a variation of the theme of restriction of women that was his specialty: he photographed super model Nadja Auermann who was supposed to be entrapped by various physical disabilities, confined by callipers and crutches, confined in a wheelchair, etc; the ultimate fetishistic gear (Figures 3.1 and 3.2). These photographs were valuable as the first introduction of physically impaired people into the world of High Fashion - a way of helping everybody accept that physical disability is not something shameful, to be hidden away¹².

¹² www.overground.be/article.php?code=74&lan=en&temp (Accessed 3rd March 2007)



Figure 3.1. Nadja Auermann for Helmut Newton, American Edition, *Vogue*, Feb.1995, p. 217

Three years later, in September 1998, some of fashion's most influential talents including Comme de Garçons, Hussein Chalayan, Owen Gaster, Roland Mouret, Philip Treacy and Alexander MacQueen were asked to come up with an outfit for eight disabled models for a special issue of the British magazine *Dazed & Confused*.

Clothes were made specifically for each individual in acknowledgement of the fact that, politics aside, people with disabilities have practical difficulties finding fashionable clothes (Figures 3.3, 3.4 and 3.5). Late Alexander MacQueen, who was also guest editor for this special issue, succeeded in challenging people's perceptions of beauty by choosing disabled model Aimee Mullins to open his dazzling catwalk show in

September's 1998 London Fashion Week. The intention behind this approach was not to be controversial, but a joyful celebration of difference. After all, it's no secret that society's way of looking at disability is still all too often to shy away from it¹³.



Figure 3.2. Nadja Auermann for Helmut Newton, American Edition, *Vogue*, Feb.1995, p. 220

¹³ *Daily Mail*, Tuesday, September 29, 1998, p. 1-5.



Figure 3.3. Aimee Mullins, *Dazed & Confused*, Sep. 1998, p. 70

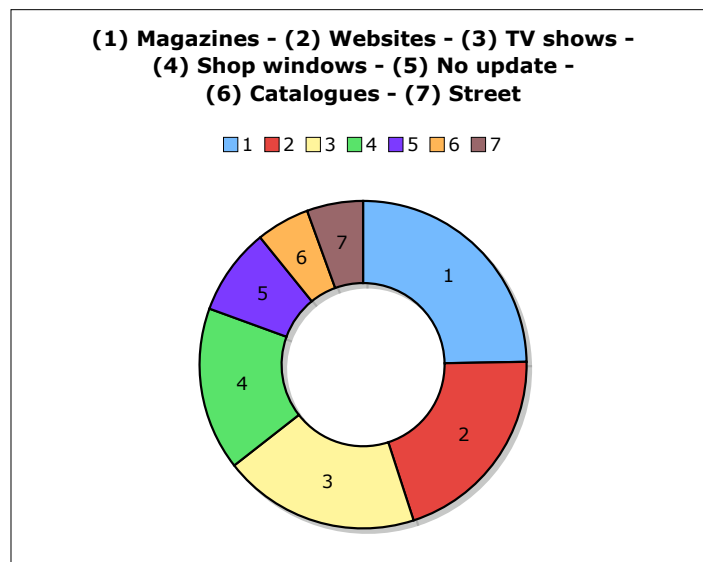


Figures 3.4 & 3.5. *Dazed & Confused*, Sep. 1998, pp. 76-77

3.6.1. Findings on the Role of the Media (TV shows, Magazines, Internet, etc) shaping Body Image of girls with AIS in Greece

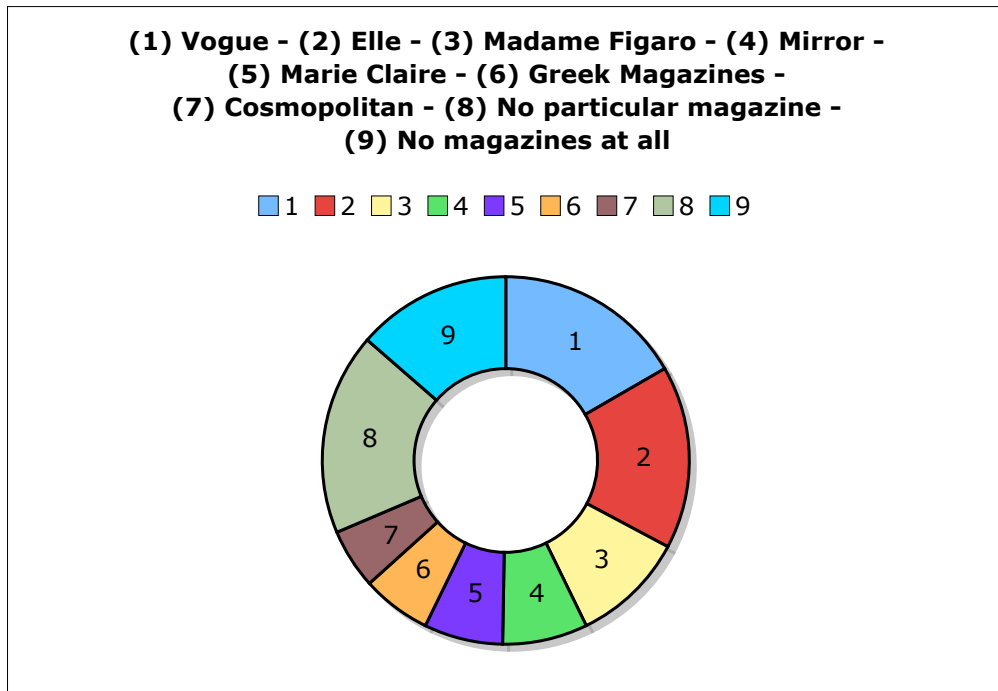
Nearly half of the sample (42.66%) stated that they were kept updated on the latest fashions via magazines, exactly one third (33.33%) via TV shows and another one third (34.66%) via the Internet, 28% via shop-windows, 9.33% via catalogues, and another 9.33% from observing what people were wearing on the streets. Only 14.66% stated that they didn't care to be kept updated at all (Table 3.19).

Table 3.19



On the one hand, *Vogue* magazine was on top of the list of preferences (29.33%), followed by *Elle* (28%), *Madame Figaro* (17.33%), *Mirror* (13.33%), *Marie-Claire* (12%), certain Greek magazines for teenagers, such as *Lucky*, *Lipstick*, e.t.c (all together counting for 10.66%) and *Cosmopolitan* (9.33%). Nearly one third of the girls (30.66%) claimed that they weren't keen on reading any particular magazine, and 24% stated that they didn't like to read any magazine at all (Table 3.20).

Table 3.20



On the other hand, more than half of the participating girls (57.3%) stated that they didn't particularly use the Internet in order to be kept updated on fashion news and latest trends, or didn't have any favourite websites. Nevertheless, *www.asos.com* website seemed to be on top of the list of the most frequently visited websites (22.66%), followed by *www.shopstyle.com* (18.66%) and *www.net-a-porter.com* (16%). *Www.victoriassecret.com*, *www.revolveclothing.com* and *www.shopbop.com*, were represented by 6.66% each, while 12% of the girls preferred various other websites (Table 3.21).

Table 3.21



3.7. The Impact of Brand Awareness on Adolescent Girls' Body Image and Identity

Teenagers represent an important demographic to marketers because they have their own purchasing power, they influence their parents' buying decisions and they're the adult consumers of the future. Industry spending on advertising to children and teenagers has exploded in the past decade, increasing from a mere \$100 million in 1990 to more than \$2 billion in 2000¹⁴.

As a result, designers need to become aware of the psychological implications generated by a product. Popular products reflect this trend and respond to the current consumer values on individual input. Many standard products, such as *Nike* shoes, *Levis'* jeans and *Mini Cooper* cars, can now be customized on websites, while they ultimately reflect the artistic taste of the user. Among teenage products, companies

often feature different styles or personalities of a product as a selling point. This personality-type pitch is also prevalent among other products, from sunglasses to nail polish. After analyzing diary entries of adolescent girls between 1830 and 1980, Brumberg (2003) had noted that, for most girls, peers have replaced parents as authoritative figures, and commercial forces have more influence than family, church, and school, while girls now value their “good looks” more than their “good works” (Brumberg, 2003:3). As evidenced by the archetype development, fashion products and accessories play a crucial role in determining physical identity. Teenage girls invest a lot of faith, self-confidence, and social emphasis in these products. For example, it is considered ‘*copycatting*’ to show up in an identical outfit, but ‘*ok*’ if it is at least a different colour. This trend towards individuality places a burden on girls to become more self-aware and self-reliant at a younger age.

Dew and Kwon (2010) conducted a four-phase research, in order to explore female college consumers’ apparel brand knowledge using students from a South-Eastern university, providing insight into the constructs of brand awareness, brand associations, and the three models of categorization, which may aid consumers when identifying and classifying apparel brands in the market (Dew & Kwon, 2010:3-18).

Another calculated survey of advertisements, conducted in 2003, in the popular teenage magazines *YM (Your Magazine)* and *Seventeen*, revealed a market segment whose security, interest, and power lie with personal products and appearance. Clothing (clothes, shoes, and accessories) is the second category of significance in which companies are spending most of their advertising budgets¹⁵, accounting for 31% and 26% accordingly, further affirming teenage girls’ interest in appearance. This interest can be seen either, as vulnerability or as a source of strength - either way, it is an inroad

¹⁴ *International Marketing Conference on Marketing & Society, 8-10 April, 2007, IIMK.*

¹⁵ April 2003 issues of *Seventeen* and *Your Magazine*.

to how teenage girls think about themselves.

Thus, following the assumption that girls like to shop, I went to various shopping malls of Thessaloniki (Greece), within the time period 2008-2012, and browsed through popular brand styles, like *Zara*, *H&M*, *BSB*, *The Gap*, *Bershka*, *Pull & Bear* and *Mango*, in order to understand what is it about the shopping experience and what teenage girls are buying, that so captivates their interest. I found out that T-shirts express something about young girls' identities, that they want people to know, or something that might start a conversation. Shopping makes girls conscious of money and prices. As their income is small to non-existent, they are looking for sales. As a result of constantly checking the tag price, teenage girls can distinguish expensive brands on other girls. Going to the mall with friends or alone is a privilege granted by parents and an adventure. Teenagers are also experimenting with their purchasing decisions and find it empowering. Credit card companies are aware of this and are marketing directly to teenagers, to give them online buying power with credit cards. Nevertheless, a teenager needs a parent's credit card to make a purchase on the Internet or a ride to and from the mall to go shopping on the weekends, which inhibits teenage purchasing patterns.

A *brand* not only encompasses all of the design concepts, but, as discovered in the character archetypes, is often more important than the products themselves.

When teenagers buy something, they are consciously buying into something: a lifestyle, a celebrity, an image, or a group of people. The advertising industry has long recognized this fact and actively develops these strong *brand identities*. Teenagers are very conscious of the message a brand sends. They can 'size' people up and categorize each other simply by what a person is wearing (Menger, 2003:53). When they buy a

product, they have considered the message and the image a company is selling. When they exchange money for this product, they are actively affirming that they believe in and are a part of that image. Sometimes, they buy the product to specifically become a part of the image.

Brand image is the most powerful way one can sell a positive message to teenage girls because it is an immediate access point to how they think and feel about themselves (Menger, 2003:45). Brand is also one of the loudest and most influential voices of authority in their culture, as evidenced by the teenager archetypes. As explained by the New York Times, “...because some teenagers have ‘bleak and atrophied familial relationships’, companies rush to create relationships with them centred on idealized notions of how their bodies should look and what they should buy. Brands become surrogate parents”¹⁶.

A healthy *self-image* should be the primary result of a supportive and encouraging home and community base. However, this is not an opportunity everyone has, and even those who are fortunate, find themselves in moments of self-doubt. Products themselves are not the final, spiritual solution, but do have an impact along a person’s journey. Industrial designers need to acknowledge a product’s everyday ability to trigger a mood or an opinion and the cumulative psychological effect. This consideration will not only promote well-being, but also prevent situations of the adverse effect. Products that invite the user and allow for sensory input inspire feelings of ownership, harmony, and connection. The product/user relationship is especially strong in the teenage years, when products become tokens of identity (Menger, 2003:86).

According to Kim and Hong (2011), fashion leadership is an important consumer characteristic due to the interpersonal influence essential in the consumption process of apparel. Based on the human motivations theory, it was examined whether fashion

leadership is related to five hedonic shopping motivations (gratification, value, social, idea, and adventure). After studying a broad national female population base, empirical evidence was offered into how fashion leadership shapes consumer need for emotional and experiential satisfaction in shopping. Results showed fashion leadership to be significantly related to all but one hedonic shopping motivation, the adventure-shopping motivation, which could be, nevertheless, derived from other types of hedonic shopping activities (Kim & Hong, 2011:314-330).

Moreover, according to Kim and Kaprova (2010), consumer motivations that can explain attitudes toward purchasing fashion counterfeit goods were examined and the underlying mechanism of intent to purchase fashion counterfeits were tested, based on the theory of planned behaviour. A random sample of 336 female college students participated in this study, whereby it was found that product appearance, past purchase behaviour, value consciousness, and normative susceptibility are significant predictors of attitude toward buying fashion counterfeit goods. Attitude, subjective norm, and perceived behavioural control are significantly related to intent to purchase fashion counterfeit goods (Kim & Kaprova 2010:79-94).

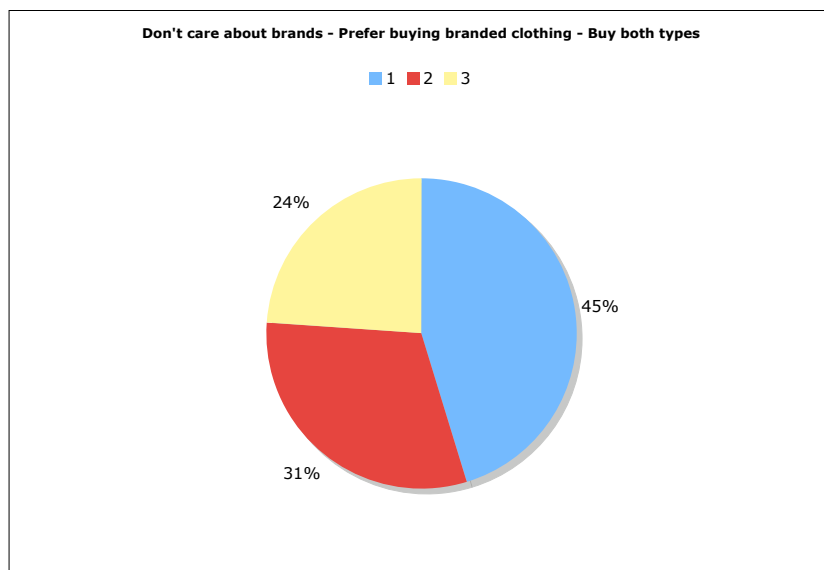
Belleau *et al.* (2007) point out that the approximately 60 million members of 'Generation Y' are a major force in the consumer marketplace and represent a significant behavioural shift. Teenage girls understand that clothing comes with a brand and a collective brand image. They understand fully the image a store is trying to convey and actively choose to buy or not buy into this image. When they purchase something, they understand and embrace the consequence of becoming part of this image. A group of girls may all want the Gap 'style', but they do not want to be wearing the exact same thing. This is *copycatting*. It is not *cool*. It is an odd paradox, wanting to be the same but different (Belleau *et al.*, 2007:244-257).

¹⁶ New York Times, January 26, 2003, quoted by Adbusters, September/ October 2003, #49.

3.7.1. Findings on Brand Awareness, Brand-name Loyalty and Brand Differentiation issues of girls with AIS in Greece

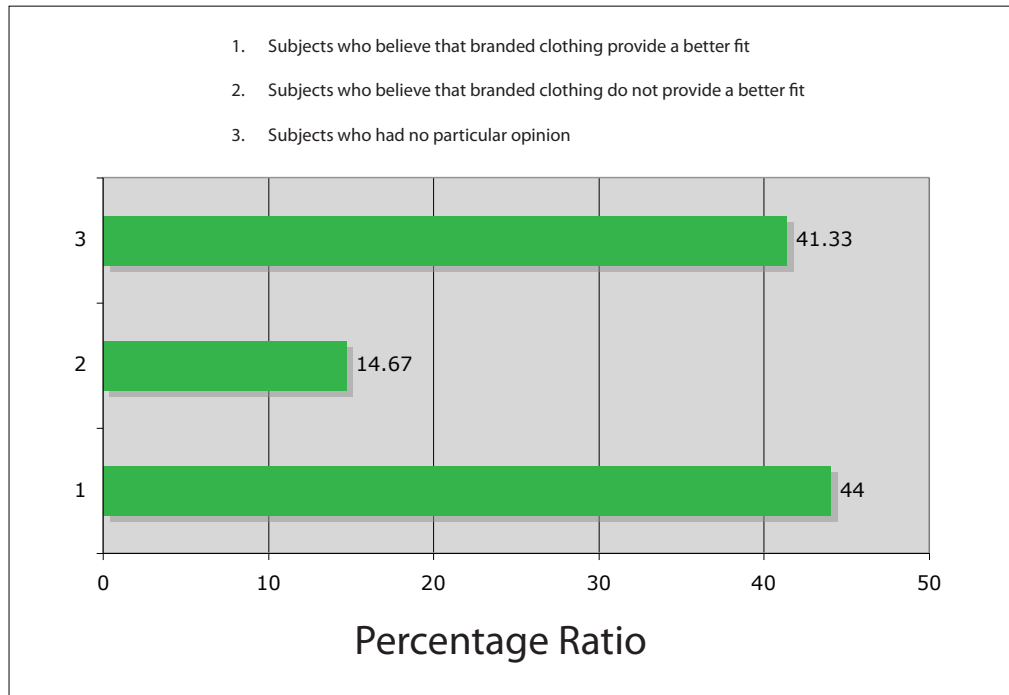
Nearly half of the participants (45.33%), in this research project, didn't care about brands, while almost one third (30.67%) would rather buy branded clothing, and nearly one quarter (24%) would buy both, either branded or non-branded (Table 3.22).

Table 3.22



In addition, almost half of the sample (44%) believed that branded clothing, in general, provide a better fit than other (non-branded) retail clothing, while only 14.67% did not. It is worth mentioning, at this point, that another 41.33% had no particular opinion on this matter, which indicates a lack of brand awareness, in terms of fit issues, of just less than half of the sample, participating in this survey (Table 3.23).

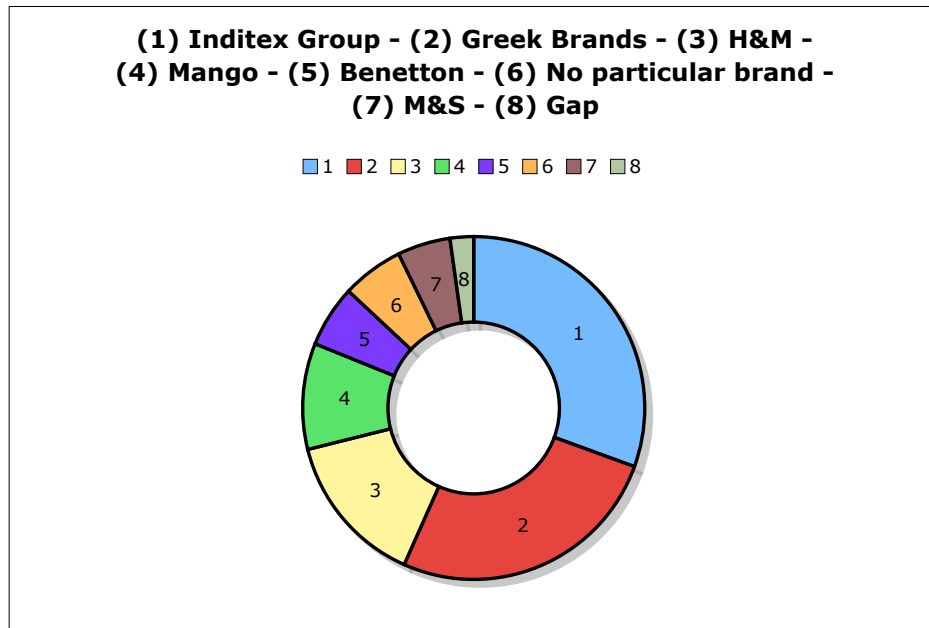
Table 3.23



Greek local brands and retail shops, like *BSB*, *Bonachero*, *Attrativo*, *Stradivarius*, *Decibel* and *No More*, were preferred by nearly half of the sample (48%). Global clothing brands belonging to the *Inditex Group* were the highest in the girls' preference list, accounting for 56%.

Bershka, *Zara*, *Pull & Bear* and *Massimo Dutti*, accounting for 36%, 34.66%, 16% and 2.66%, respectively, were followed by other international brands like *H&M* (26.66%), *Mango* (18.66%), *Benetton* (10.66%), *M&S* (9.33%) and *Gap* (4%). Only 10.66% of the whole sample either didn't have any favourite clothing brands, or couldn't remember any of them (Table 3.24).

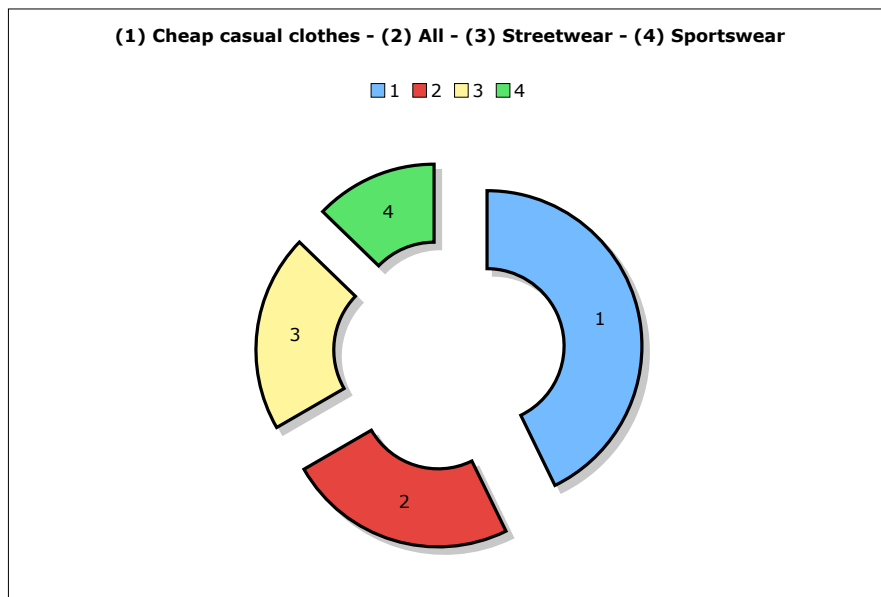
Table 3.24



Almost three quarters of the sample (72%) would buy mostly cheap, casual clothing, while less than half of the sample (40%) would buy many different kinds or styles of clothing, and not just one particular style. At this point, it is interesting to see that streetwear and jeanswear brands (34.66%), like *Levi's* (25.33%), *Diesel* (21.33%), *Replay* (5.33%), *Lee* (1.33%) and *Edward* (1.33%) were higher in the girls' preference list, compared to sportswear brands (21.33%), like *Adidas* (14.66%), *Nike* (13.33%), *O'Neil* (6.66%) and *Puma* (2.66%) (Table 3.25).

Designer labels such as *Marc Jacobs*, *Louis Vuitton*, *Sonia Rykiel* and *Valentino* formed only 5.33% of the list of preferences, while middle-market brands such as *Juicy Couture*, *Joseph*, *Cop-Copine*, *Miss Sixty*, *Fornarina* and *Custo Barcelona* accounted for 14.67%, indicating that the remainder 80% would rather buy clothes mainly from the rank, in high-street clothing stores, or simply, didn't care where they would go buy their clothes from.

Table 3.25

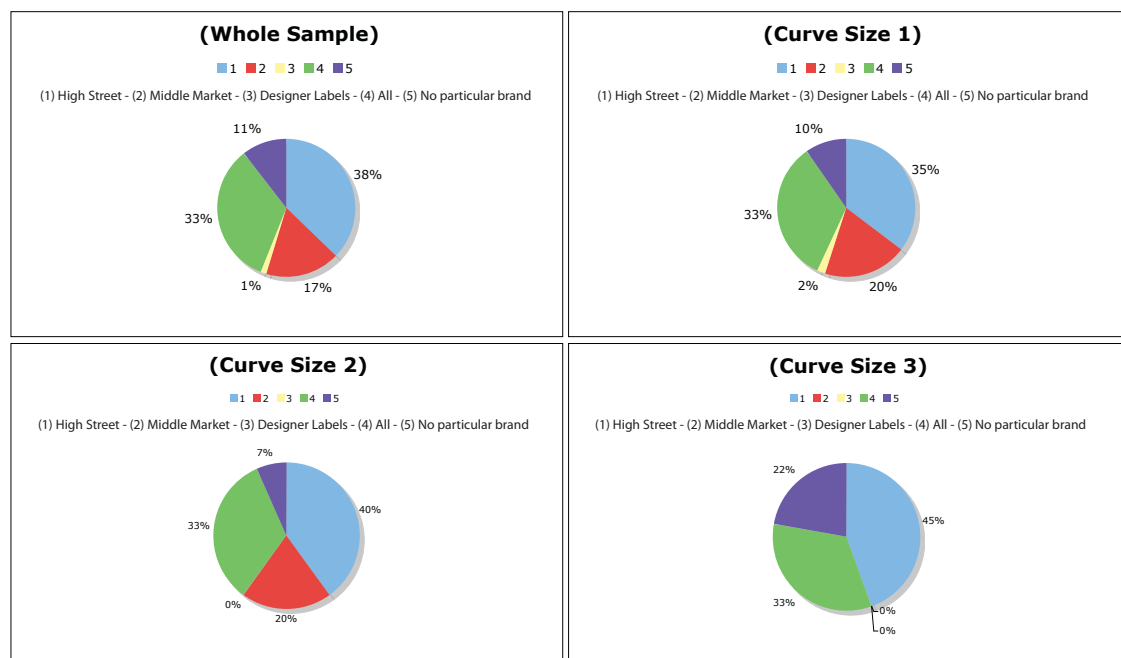


The majority of the sample (37.33%) preferred to shop from high-street clothing stores, while exactly one third (33.33%) would buy, not only cheap, throw-away clothes from the rank, but also more expensive middle-market brands, too. It is quite interesting to see that this percentage - exactly one third of the sample - who buys both cheap and middle-market branded clothes, remains the same (33.33%) for each one of the three different curve-sized groups, separately (Table 3.26).

More specifically, over one third of the girls with mild deformities (35.29%) would buy their clothes from the high-street, while exactly another third (33.33%) would buy their clothes, either from the high-street, or from middle-market stores. It is also worth mentioning that only 1 girl out of 75 stated that she preferred to buy only designer labels, and this particular girl belonged to the group of girls with mild deformities (Curve Size 1). Moreover, 40% of the girls with moderate deformities would prefer the high-street stores for shopping, whereas 20% would prefer to buy only middle-market branded clothing, and 33.33% would buy both.

Notwithstanding, the highest percentage of girls who preferred the high-street clothing stores for shopping (44.44%), or who didn't remember having any particular favourite brand (22.22%), belonged to the group of girls with severe deformities. This survey also shows that girls with serious deformation didn't buy any middle-market brands or designer labels, which indicates that they seem to avoid spending money on expensive clothing, or do not care much about brands (Table 3.26).

Table 3.26

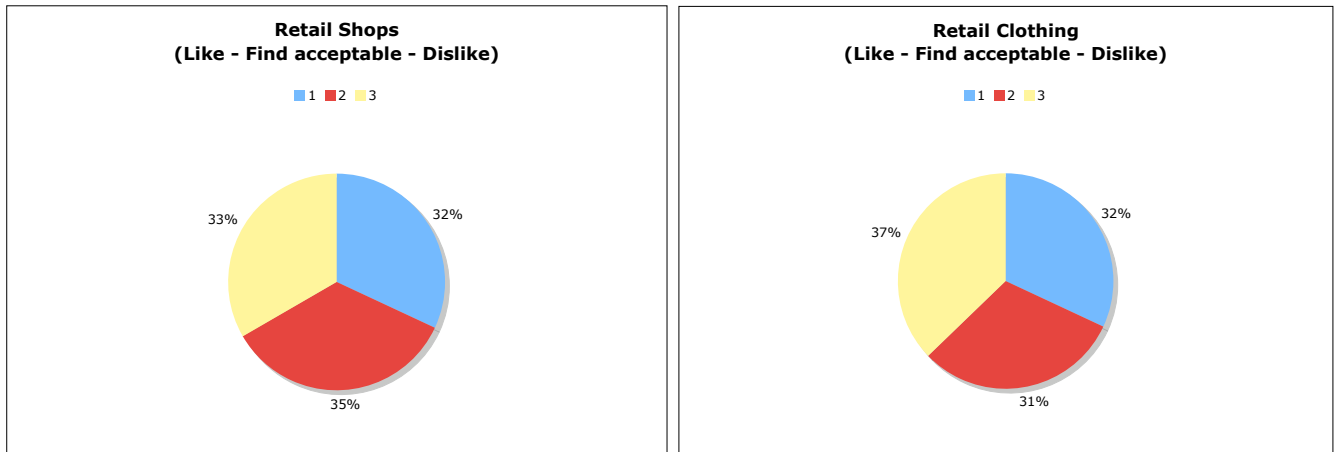


3.7.2. Findings on Retail Clothing Brands' and Stores' preferences of girls with AIS in Greece

The whole sample of girls with scoliosis, participating in this research project, was divided, nearly equally, to girls who expressed a strong like for both retail shops and clothing (32%), those who found the shops quite acceptable (34.66%) or the clothes

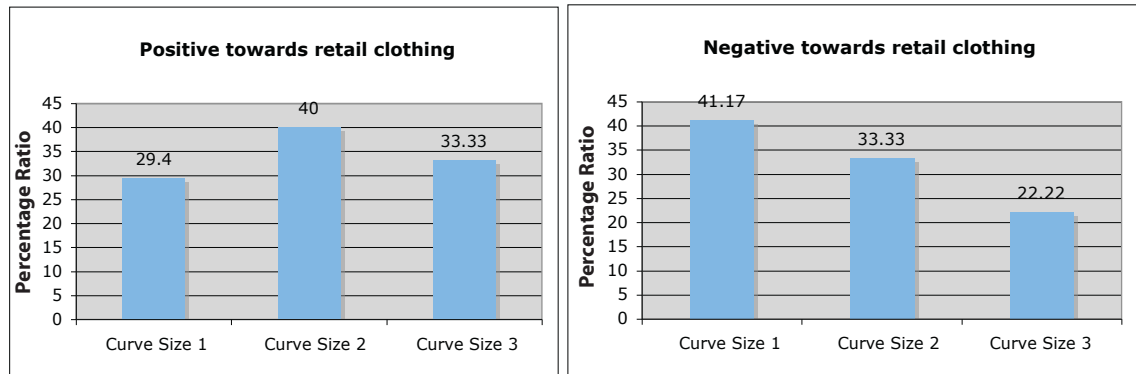
quite ordinary (30.66%) and those who liked neither the shops (33.33%), nor the clothes (37.33%). Therefore, it seems that the majority of the sample was rather satisfied from the retail shops and clothes in the Greek market: 66.66% thought that retail shops were quite nice, when 62.66% found retail clothing quite acceptable (Table 3.27).

Table 3.27



At this point, it is interesting to see that the majority of the girls (77.77%) with apparent disfigurement (Curve Size 3) found retail clothing acceptable, while only 33.33% claimed to be really keen on them. On the contrary, 22.22% of the same group expressed dislike for conventional retail clothing, this percentage being the lowest, compared to the percentage referring to girls presenting moderate (Curve Size 2) or mild (Curve Size 1) spinal curvature (33.33% and 41.17%, respectively) (Table 3.28).

Table 3.28



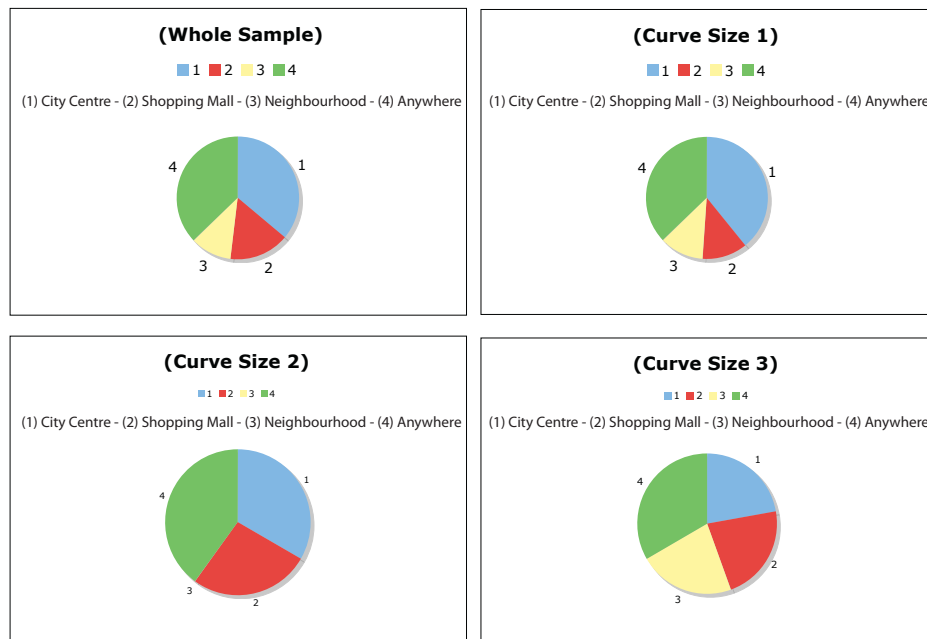
Therefore, it is evident that, concerning retail clothing, girls with moderate spinal curvature (Curve Size 2) were the most favourable group, whereas girls with mild spinal curvature (Curve Size 1) were the least favourable.

These findings reinforce, once again, the researcher's belief that certain subjects might have been 'putting on a brave face' when filling out the questionnaire, in order not to be considered as set apart from their peers.

To conclude, the questionnaire also indicated that more than one third of the sample (36%) preferred to go shopping in the centre of the city, because they claimed to find, there, a bigger variety in clothes, while they stated that the shops in the centre were better updated on fashion trends. Other girls preferred to go shopping in big shopping centres, outside the city (16%), or to shops in their neighbourhood (10.66%), while the highest percentage (37.33%) were girls who didn't care where they would go shopping, as long as they went shopping. It is also worth noting, that girls with mild spinal curvature preferred to go shopping in the centre of the city (39.21%) or didn't care where they would go shopping, as long as they could find clothes that they liked (37.25%), while 40% of the girls with moderate deformities and exactly one third (33.33%) of the girls

with severe deformation also didn't care where they would go shopping. None of the girls with moderate deformities went shopping in their neighbourhood, while the highest percentage (22.22%) of the girls who preferred to buy their clothes from shops in their neighbourhood, belonged to the group of girls with severe deformities (Table 3.29).

Table 3.29



3.8. Questionnaire Conclusions

Questionnaire results of this study demonstrated a variety in subjects' with scoliosis responses, pointing out that adolescent girls' with scoliosis tastes, preferences and needs can be as diverse as society in general.

Given that most of the subjects in this research's scoliotic sample presented a mild spinal curvature (67.56%), while subjects with a moderate and a severe spinal curvature represented, together, 32.43% of the sample (Table 2.3, p.24), the above findings do not clearly demonstrate the need for clothing to conform to scoliosis, owing to the fact that

the visual outcome of the deformity is not so evident in the two thirds of the sample: the scoliotic curve gets more prominent when the degrees of scoliosis increase, causing difficulty in fit into certain conventional retail clothing, due to the body's asymmetry between the right and left side.

Furthermore, although certain questions in this survey, such as questions 15 and 16 (see the questionnaire, Appendices A1 and A – Participants' Responses) were addressing the same matter in a different way, asking for similar answers from the participants, the received responses were rather contradictory, a fact that pinpointed the researcher's initial belief, indicating that certain subjects might have been 'putting on a brave face' when filling out the questionnaire, in order not to be considered as set apart from their peers.

In conclusion, seen through the researcher's personal perspective, the individual with a deformity of the spine can feel embarrassment and shyness because of defects of self-image caused by posture impairment or disability. This can lead the individual to avoid participation in social activities (WHO, 2002:17).

Designing clothing for individuals' with scoliosis satisfaction, therefore, requires understanding individuals with scoliosis and their needs, while it also requires thinking of product properties in terms of perceptual, kinaesthetic and emotional responses.

If people with divergent body figures, who currently face problems finding ready-to-wear clothing suitable for them, could get clothes that fit them - in terms of style, comfort, fit, and appearance – it would improve their participation in social activities and in life, in general.

Chapter 4

The Past, the Present and the Future of Clothing Females with Non-standard Body Figures – Emerging Issues and Future Perspectives

4.1. Previous Initiatives

Only in the last 20 years fashion has grown in importance, in the area lying between disability studies and apparel design, while to date, minimal work has been undertaken in terms of pattern or fashion design for unique figures. Various studies have explored functional aspects of clothing design for women with disabilities, but only few have succeeded in blending functional with fashionable / aesthetic aspects accommodating an inclusive design approach (Chase & Quinn, 2003:5).

Research on the subject of clothing for the disabled community began in the 1950s following World War II and the Korean War, while in the USA, a strong civil rights movement resulted in the US Supreme Court Decision of 1954, that provided a model for the disability movement. The Vietnam War was another key factor, since a high promotion of wounded survived - due to the rapid evacuation of casualties by helicopter - resulting in a significant swelling in the numbers of young disabled people, in particular wheelchair users, who found themselves in a world that was not at all disability-friendly (Clarkson *et al.*, 2003). Moreover, until the 1970s, most adaptive clothing were clinical in nature and appearance, calling attention to itself and the wearer in a negative way, because it addressed the disability, rather than the person wearing the garment (Chase & Quinn, 2003:5).

On 1st January 1997, EASYTEX (aesthetical, adjustable, serviceable and mainstay textiles for disabled and elderly), an EC-funded project, supported by the '*Telematics Applications*' programme of the European Union, commenced officially and was to run for 3 years. The project partners were from France, Greece, Sweden, UK and Finland, while the project addressed two main categories of need: the need for clothing for people who have problems with dressing/undressing, fasteners, etc. where difficulties occur with the clothing itself; and the need for clothing with improved design and construction for people with non-standard body shapes (Scott, 2005). The results of the project (1997-2000) were the build up of a database in order to improve the availability of information on clothing and textiles for the disabled and elderly, and the development of a system that enables the industrial production of individually-modified clothing, by using automated body-scanning techniques and altering standard patterns, according to individual dimensions. Pattern construction for unique figures was covered in a study carried out at Göteborg University, reported in the licentiate thesis '*Tailoring the unique figure*' by Niina Hernández. The main body of the study contained three sections: body figure registration (including measurements), single pattern adaptations and individual patterns (Meinander & Varheenmaa, 2002).

Concurrently, *The Helen Hamlyn Centre for Design* at the Royal College of Art, London, became a fully-fledged research centre in 1999, widening its focus from design for ageing population to design to improve people's lives across a range of social needs. *The Helen Hamlyn Centre's* approach is inclusive and interdisciplinary, and their work is organised in three research labs: age and ability, health and patient safety, and work and the city¹⁷.

¹⁷ www.hhc.rca.ac.uk/ (Accessed 20th May 2012)

Nearly at the same time, from April 1998 to early 2000, CAESAR (Civilian American and European Surface Anthropometry Resource), a government-sponsored body scanning technology study done in the US, the Netherlands and Italy (Weathers, 2007)¹⁸, was funded by the automotive, airline, and apparel industries and its data was used in the design of many products. Initially conceived by the US Air Force, it was an international survey of body sizes and shapes of people between ages 18-65, while its data collection methods were standardized and documented so that the database could be consistently expanded and updated. Subsequent phases could add other age groups, other countries, or look at trends over time within countries¹⁹.

In 2001, the SizeUK study²⁰ (the UK National Sizing Survey), a consortium of 17 major UK leading Clothing high street retailers, leading academic institutions, technology companies and the UK Government, under the direction of Philip Treleaven, professor at UCL (Wells *et al.*, 2007:419-425) – attempted to identify up-to-date body size and shape differences among various demographics, in order to provide better-fitted clothing for consumers (Apeagyei, 2010: 58-67). This research involved Treleaven's collaboration with his colleague Prof. Bernard Buxton, Jeni Bougourd of the London College of Fashion and Andrew Crawford of Bodymetrics (Inns, 2007:306). Using the '[TC]² 3D body scanner, 11,000 men and women from various parts of Britain were measured (Size UK, 2009), using 3D whole body scanners. The 17 major retailers involved, were responsible for recruiting subjects to be measured, with subjects being encouraged to register online. The principal UK clothing colleges (*LCF, Nottingham Trent* and others) managed the data collection process, seen as an educational opportunity. The USA

¹⁸ Weathers, N. (2007). Sizing up garment fit issues. In: http://www.just-style.com/analysis/sizing-up-garment-fit-issues_id98055.aspx (Accessed 20th May 2012)

¹⁹ CAESAR uses latest laser technology. (Retrieved September 27, 2002). In: <http://www.sae.org/technicalcommittees/caelaser.htm> (Accessed 13th October 2011)

scanner company [TC]² developed special size extraction software to automatically extract 150 'SizeUK' measurements from each body scan, reducing manual measuring to just 8 measurements, such as height and weight. The headline results were announced in 2004.

One year later, in 2002, '[TC]² initiated SizeUSA²¹ - a U.S. National Sizing Survey associated with the 'CAESAR' study, using a sample size of 10,000 men and women selected from major cities across the United States. According to Dr David Bruner, vice president of technology development, and Jim Lovejoy, director of industry programs, [TC]²'s SizeUSA study has been used to date, by more than 50 clothing companies.

According to the National Textile Centre's Annual Report in November 2003, Susan Ashdown & Suzanne Loker (Cornell University) had developed a prototype mathematical process, using body scan data to improve sizing systems for specific target market populations²².

Four years later, in 2007, the Ashdown-Loker research extended the findings from their first NTC project (S01-CR01)²³ by developing methodologies for applying a combination of fit and anthropometric population data to the problem of developing effective sizing systems for apparel products. Measurement data were collected for target markets by gender, age, and niche functional markets relevant to clothing fit, while they also linked their scan data set with the SizeUSA anthropometric data to establish it as statistically representative of the sample of the target market in the U.S. population. Their goal was

²⁰ <http://www.tc2.com/history.html> (Accessed 18th May 2012)

²¹ <http://www.tc2.com/history.html> (Accessed 18th May 2012)

²² NTC Project: S01-CR01 (formerly S01-B01) In: <http://www.ntcresearch.org/pdf-rpts/AnRp03/S01-CR01-A3.pdf> (Accessed 22nd October 2012)

²³ Ashdown, S. Loker, S. co-leaders (Cornell); Rucker, M. (UC Davis) (2007). Improved Apparel Sizing: Fit and Anthropometric 3D Scan Data. National Textile Center Research Briefs: June 2007. In: <http://www.ntcresearch.org/pdf-rpts/Bref0607/S04-CR01-07.pdf> (Accessed 13th March 2012)

to develop and test a virtual sizing system that compares measurements from a garment created from 3D geometric shapes to the scanned 3D measurements of the target population to improve fit. The results of this fit comparison would govern the 2D pattern changes required to create sizes that fit the highest percentage of the target population²⁴.

Since the first application of a 3D body scanner for a national survey (Size UK), body scanners have been used for several national size surveys for example in USA, China, Spain, Mexico, Thailand, France, Korea and Taiwan (Apeagyei, 2010:58-67).

Additionally, the UK Ministry of Defence, India, Brazil and Australia are interested in conducting their own sizing surveys, serving the international apparel industry on issues of supply chain strategy, body scanning technology, mass customisation business models, establishment of fit criteria, and improved technologies for pattern making and digital fabric printing (Weathers, 2007).²⁵

4.2. Current Provision

The SizeUK consortium was supported by a UK company, called '*Sizemic*', that worked in partnership with the SizeUK Retailers, in order to exploit the commercialization of the data and maximize the benefits. *Sizemic* is, to date, hosting the data on a secure, web-database service, accessible through proprietary online data analysis tools and has the exclusive rights to sell the data on behalf of the Retailers.

Unlike the traditional approach to pattern development *Sizemic* patterns are based on 3D body morphology i.e. *body shape*, since shape is more important than pure

²⁴ Ashdown, S. Loker, S. co-leaders (Cornell); Rucker, M. (UC Davis) (2007). Improved Apparel Sizing: Fit and Anthropometric 3D Scan Data. National Textile Center Research Briefs: June 2007. In: <http://www.ntcresearch.org/pdf-rpts/Bref0607/S04-CR01-07.pdf> (Accessed 13th March 2012)

²⁵ Weathers, N. 2007. *Sizing up garment fit issues*. In: http://www.just-style.com/analysis/sizing-up-garment-fit-issues_id98055.aspx (Accessed 23rd September 2011)

measurements in determining *fit*. This is a leading edge, innovative and scientific approach to pattern development using Parametric Pattern Generating (PPG) software developed by *Sizemic*'s technology partner TPC (HK) Ltd, a garment technology consulting firm, based in Hong-Kong, that specialises in offering fashion house & garment manufacturer solutions to problems encountered during the course of design & production, particularly in the pattern creation process. More specifically, *TPC* employs a completely different approach by starting with a series of human body data obtained from a 3D body scanner and employing advanced computer graphic applications to smoothen the 3D body image into a framework consisting of regular mesh. The treated image, called '*Virtual Mannequin*', can be deformed into whatever shapes based on different human body profiles obtained from scanning. Through a process of human body structural definition, a set of reference lines is obtained as the key parameters for the construction of garment patterns based on the *TPC* 3D pattern concept method. 3D relational-geometry is used to automatically convert 3D pattern constructions into 2D pattern blocks. The pattern blocks thus created are akin to those stripped off from a 3D garment form, making the attainment of '*fit*' much easier.²⁶

In addition, *SizeUK – PPG* is a 3D pattern development service, available for womenswear and menswear,²⁷ whereby garment structures (3D patterns) are developed in a 3D environment on a range of customized or generic virtual mannequins - one for each size in the range. The software simultaneously generates 2D patterns from these 3D structures. Morphological grading ensures that the fit is replicated in all sizes and based on the 3D body shape of each size, while the result is greater accuracy of fit and better fitting garments in *all* sizes. Hence, the commercial benefits for Retail clothing

²⁶ <http://www.tpc-intl.com/software.asp> (Accessed 31st May 2012)

²⁷ <http://www.sizemic.eu/products-and-services/pattern-development.html> (Accessed 18th April 2012)

brands acquiring the data are enormous²⁸, providing the potential amongst others to improve sizing and fit, to optimize the efficiency of their size charts, to maximize the percentage of their target customer profile that can fit their clothes, to increase sales by understanding the demand in certain size categories (e.g. outsize, petites), to reduce size related returns and to improve buying ratios and size allocation to retail branches. SizeUK carried out the first National Survey of the UK adult population since the 1950's and was the first survey in the world to use 3D whole-body scanners to automatically extract measurements. The results showed that over 60% of UK shoppers had difficulty finding clothes that fit, and that average female waist size had increased by 16.5 cm since the 1950's. The SizeUK retailers have used the data to update their size charts, improve garment fit and maximise the percentage of their customers that can fit their clothes.

Establishing, therefore, a relationship between body size and shape in the provision of adequate clothing is vital. Recently, Dr Caterina Radvan, a knitwear designer and Senior Lecturer at London College of Fashion since 2011, followed an inclusive design methodology for her research, where the needs of severely disabled women (extreme users) were established in order to inform the design of a knitwear collection, focusing on design development through consideration of the needs of the end-user and the exploitation of the capabilities of advanced industrial seamless knitting technology, in order to design fashionable knitwear for a wider section of the market than is catered for at present (Radvan, 2011).

Meanwhile, a growing number of mail order companies are currently offering garments, which are both adaptive and fashionable, as well as appropriate devices and accessories. By searching websites of ready-to-wear adaptive clothing stores like

²⁸ <http://www.sizemic.eu/products-and-services/size-survey-data.html> (Accessed 18th April 2012)

'Able2wear', 'Adaptive Clothing Showroom', 'Adaptawear', 'Anitavee's Adaptive Apparel' or 'Buck and Buck Designs', looking at their trend services and observing the marketplace, it is apparent that women with disabilities might find easily accessible options to augment their wardrobe. Nevertheless, most adaptive clothing patterns mostly focus on the needs of wheelchairs users, giving solutions for clothes from a seated perspective, home health care seniors and nursing home residents or handicapped users, while this does not diminish the fact that designers and product developers could do more to appeal to women with disabilities, in general, in terms of pattern design. The problem of finding suitable clothes for the disabled or for individuals with distinctive body configurations, firstly depends on their disability / deformity and, secondly, on the lack of technical solutions. Products that open in the back can help ease the dressing process, like adaptive nightgowns, adaptive dresses, adaptive sweat-suits, adaptive nightshirts, adaptive shirts or blouses. For example, '*Adaptawear*' designs manufacture a range of ladies and gents open-back and drop-front trousers, open-back and magnetic fastening shirts and blouses, open-back nighties and the unique magnetic front fastening COREBRA.

Most of these companies consider that, although making custom clothing from scratch is ideal, adapting ready-made garments can also work well. However, there are many designers and clothing manufacturers who are realizing now that people in wheelchairs, or people who are otherwise disabled, cannot easily wear clothing designed for the able-bodied. Clothes don't look as flattering when one is sitting down, nor are comfortable if seams are hitting pressure points or rubbing against sensitive skin all day long²⁹.

²⁹ <http://disability.about.com/b/2012/02/27/clothing-for-the-disabled-improving.htm> (Accessed 19th May 2012)

Companies, however, focus too much on the '*specialty*' solutions, while they seem to ignore the fact that there are so many individuals who are in need of made-to-measure garments, and not necessarily of other technical or '*specialty*' solutions, than those offered in conventional retail clothing. For instance, wheelchair users or other categories of disabled people are not standard sized, and alterations of specially designed and relatively expensive clothing still might be necessary; to have the garments tailor-made is very expensive, and requires special tailoring skills. In such cases, the garment fit and the technical solutions should be available separately or combined, when necessary. Nevertheless, there are several companies, like '*Dignity By Design*', or '*Professional Fit Clothing*', whose product development teams launch research into what their consumers' needs are, allowing them to discover new concepts in pattern development and manufacturing apparel for the disabled, that revolutionize clothing choices for a populace that is more than often, and historically, overlooked. Some of these companies' concepts go far beyond replacing buttons with VELCRO: apart from using soft, breathable and wrinkle-resistant fabrics, they adapt their consumers' crotch rise, shoulder and waist variances into the produced patterns, with standard sizing, well before the latter reach their manufacturing plants. Thus, through extensive research, they design prototype ergonomically correct patterns for the physically challenged and wheelchair mobile.

The priority of most of the above companies in designing for the disabled, has traditionally been to enable, while attracting as little attention as possible, and their designs are carefully chosen for the ability to camouflage their '*specialty solutions*' such as back-openings or VELCRO closures. *Design for Special Needs*, in general, exists in the middle ground between two extremes: using bright colours to emphasize the clothing's '*special solutions*' (e.g. brightly coloured jackets for wheelchair users), or flesh-coloured devices for camouflage. The approach, so far, has been less about projecting a

positive image than about trying not to project an image at all. On the one hand, invisibility is relatively easy to define, and may even be achieved through technical and clinical innovation alone, but it is more difficult to define a positive image purely from these perspectives. Fashion, on the other hand, might be seen as being largely concerned with creating and projecting an image: making the wearer look good to others and feel better about themselves. Hence, sincere and respectable design requires a far more skilled and subtle approach – one that is less easy to articulate than these two extremes.

4.3. Current Approaches to Design for the Disabled or People with diverse Body Configurations and Needs

Today, legislation, demographics and economic realities create new markets as a result of increased understanding of what consumers at all levels of the population really want. Most western economies, today, are overfilled with physical products, and while industrial production has become more efficient in economic terms, the great quantity of products and services, and the way they are used and consumed, appears to inhibit the social trail toward sustainability (Gardner *et al.*, 2004:3-21).

The *Centre for Sustainable Fashion*, in the London College of Fashion, UAL, has developed a set of 'tactics for change' in three key areas: building a transformed fashion system, fostering human well-being and working with nature's limits³⁰. Moreover, various events, such as the annual '*Fashioning The Future Awards*'³¹, the biennial '*Include*' International Conferences³², the 11th annual conference for the '*International Foundation*

³⁰ <http://www.sustainable-fashion.com/challenging-what-we-do/tactics-for-change/> (Accessed 19th May 2012)

³¹ <http://www.sustainable-fashion.com/fashioning-the-future/> (Accessed 19th May 2012)

³² <http://www.lhc.rca.ac.uk/448/all/1/include-conference.aspx> (Accessed 11th June 2011)

of *Fashion Technology Institutes*' (IFFTI) in April 2009³³ and the Hohenstein Institute's 'MedTex' Symposium 2010³⁴ have been celebrating unique ways to create our futures, by merging the concept of fashion with the concept of well-being. Meanwhile, the way disability is defined and understood has changed in the last decade, since 'The Americans with Disabilities Act' (ADA) in 1990 and the U.K. 'Disability Discrimination Act' (DDA) in 1995. Disability was once assumed as a way to characterize a particular set of largely stable limitations. Recently, the World Health Organization (WHO, 2002) has moved toward a new international classification system, the International Classification of Functioning, Disability and Health (ICF 2001)³⁵, which provides a platform that supports 'Human-Centred Design' and 'Universal Design' as an international priority for reducing the experience of disability and enhancing everyone's experience and performance³⁶.

4.3.1. User-centred or Human-centred Design

'Human-Centred Design' (HCD), also called 'User-Centred Design' (UCD) is a design philosophy and a process in which the needs, wants, and limitations of end users of a product are given extensive attention at each stage of the design process. User-centred design can be characterized as a multi-stage problem-solving process that not only requires designers to analyse and foresee how users are likely to use a product, but also to test the validity of their assumptions with regards to user behaviour in real world tests with actual users. What makes it different from other product design philosophies is that user-centred design tries to optimise the product around how users can, want, or need to

³³ <http://www.fashion.arts.ac.uk/IFFTI.htm> (Accessed 19th September 2009)

³⁴ <http://www.innovationintextiles.com/hohenstein-institute-hosts-medical-textiles-symposium/> (Accessed 12th June 2011)

³⁵ <http://www.who.int/classifications/icf/en/> (Accessed 22nd May 2012)

³⁶ <http://www.humancentereddesign.org/index.php?option=Content&Itemid=3> (Accessed 7th March 2012)

use the product, rather than forcing the users to change their behaviour to accommodate the product³⁷.

One basic philosophy of *UCD* is to listen to users and to take their complaints and critiques seriously. Unfortunately, sometimes acceding to users' requests can lead to overly complex designs. *User-Centred Design* can lead to clear improvements of bad products, trying to avoid failures and to ensure that products do work, that people can use them.

The *Institute for Human Centred Design* (IHCD) - founded by Elaine Ostroff and Cora Beth Able, as an outgrowth of the Arts and Human Services Project, is an international non-profit organization committed to advancing the role of design in expanding opportunity and enhancing experience for people of all ages and abilities through excellence in design³⁸. Since 1978, it has evolved, and at any given time, projects are likely to include varying proportions of focus on accessible design as required by law (Section 504 and 508 of the Rehabilitation Act, IDEA, Fair Housing, the Americans with Disabilities Act) and human-centred or universal design that works seamlessly for people with disabilities and older people but also enhances everyone's experience. Elaine Ostroff coined introducing the term '*user/expert*' to describe the role of ordinary people with valuable life experiences who could inform the design process. Children and adults with disabilities and older people have expertise about design that is mostly overlooked by people designing for an imagined norm. As the population becomes more diverse in age and ability, notions of majority norms have less relevance.³⁹

Apparently, a new-design energy has been building around the world and is generating products and places that respond to a positive fact of the 21st century: people live longer

³⁷ <http://www.humancentereddesign.org> (Accessed 7th March 2012)

³⁸ <http://www.humancentereddesign.org> (Accessed 7th March 2012)

and survive more than ever before.

4.3.2. Universal or Inclusive Design

The evolution toward *Universal Design* began in the 1950s with a new attention to design for people with disabilities. By the 1970s, parts of Europe and the United States were beginning to move beyond the emphasis on '*special solutions*' tailored to individuals and toward the idea of *normalization* and *integration*. A number of trends converged in the 1980s. People with disabilities had organized themselves in many nations to be appropriately termed the '*disability community*' and able to articulate shared perspectives. They were increasingly concerned about an evolving dichotomy of '*us*' and '*them*' that rested on false assumptions about disability being a rare and static condition. They noted the unintended consequence that laws governing accessible design had reduced design to a set of minimum requirements too often resulting in designs that were accessible but felt separate and unequal. In 1987, a group of Irish designers succeeded in getting a resolution passed at the World Design Congress that designers everywhere should factor disability and aging into their work. The United States, led by the disability community, established the most expansive legal requirements with the passage of The Americans with Disabilities Act (ADA) in 1990.⁴⁰

Universal Design is human-centred design of everything with everyone in mind - also called *Inclusive Design*, *Design-for-All* and *Lifespan Design*. It has a parallel in the '*Green Design*' movement that offers a framework for problem-solving design based on the core value of environmental responsibility. *Inclusive Design* is an approach to creating environments and products that are usable by all people to the greatest extent

³⁹ <http://www.humancentereddesign.org/index.php?option=Content&Itemid=11> (Accessed 7th March 2012)

possible (Mace *et al.*, 1991:156), while some people claim inclusive design is about maximizing products market potential by making sure the maximum number of people can use them (Clarkson and Keates, 2003). On the contrary, the concept of '*Inclusive Design*' is not a proposal for all products to be accessible to all people, which even if it were possible, would lead to an uncomfortable and uneconomic uniformity. It is a plea for designers and manufacturers to help themselves, as well as their customers, by looking more closely at the profiles of the people whom they expect to purchase and use their products and taking time to study the spectrum of size, shape and ability of their customers, and not just their spending habits. In this way, they might find they could make better, more desirable items at no greater cost and would gain access to wider markets, so that people with disabilities would not have to seek special solutions, when what they really want is, simply, good design.

As future consumer markets will be more diverse than ever in terms of age and physical ability, these two major trends – population ageing and the growing movement to integrate disabled people into mainstream society - have driven the growth of '*Inclusive Design*'.⁴¹ *Inclusive Design* should become intrinsic to good design, firstly, due to the fact that design is powerful and profoundly influences our daily lives and our sense of confidence, comfort, and control; and secondly, because variation in human ability is ordinary, not special, and, affects most of us for some part of our lives. Following Gibson (1979), as we grow older, get pregnant or experience some accident or illness our abilities change – our perception and experience shows a discrepancy between what we think we can do and what we actually manage. And since our man-made environment is built to support average abilities, we are disabled. Thus, designing for children, elderly

⁴⁰ <http://humancentereddesign.org/universal-design/history-universal-design> (Accessed 15th December 2012)

and people with disabilities is not thinking about separate groups of users, but about a spectrum of human-environment interaction (Byerts, 1977:31). In addition, it is very important to realize that disabled people do not want specially designed products or to be separated from the community in any way.

Therefore, *Universal Design* is a framework that accepts diversity of ability and age as the most ordinary reality of being human, and evaluates strategies and solutions based on how well they meet the needs of the widest possible group of potential users and enhance everyone's experience. It demands a quality of creativity and invention that can energize generations of designers to become partners with users in a revitalized appreciation of design as intrinsic to social sustainability⁴².

Historically focused on older people and disabled people, *Inclusive Design* now needs to address other excluded groups, refocusing on the expertise gained from product design and the built environment, so that other design disciplines such as fashion, new media and service design can engage. The focus now should be on better mainstream solutions for everyone, supported by new design research techniques to make the development process more user-centred. More collaborative approaches should be developed, where designers and users work on an equal footing to create ideas and this should be brought into commercial development processes and timeframes.

Inclusive design is, in many ways, a reaction to design, in general, which has demonstrably and repeatedly excluded certain groups of people. It is important, though, to keep the term '*design*' in '*inclusive design*', so that exquisite design is still valued within inclusive design. If *inclusive design* marginalised design in general, it would be itself that would be marginalising. Everyone can use inclusively designed products. The

⁴¹ <http://www.designcouncil.info/inclusivedesignresource/> (Accessed 22nd September 2008)

question is whether we want to or not. The current focus on usability and utility in inclusive design reduces the importance of issues such as people's emotions, values, hopes and fears, disregarding the very essence of what makes us human, while inclusively designed products risk being irrelevant to larger customer groups and stigmatising to those who need them (Naess & Oritsland, 2005). On the contrary, products that are designed with the above issues in mind could reach a wider group of customers and would be highly usable. Therefore, *Inclusive Design* should become more open to absorbing positive influences from design, in general, while adapting and adopting more radical approaches, even those that may not at the moment be producing inclusive results. This should not be seen as being contradictory to inclusive design's role, due to the fact that the more resonance there is, the more influential inclusive design can become.⁴³

4.3.3. Design for Disability⁴⁴

Graham Pullin (2009:2) in his book '*Design meets Disability*' clearly demarcates the terms of '*Mainstream Design*', '*Inclusive Design*' and '*Design for Special Needs*', suggesting the looser term '*Design for Disability*' (Pullin, 2009:2). This is a more acceptable term, encompassing all the above terms and other activities that challenge the division between designing for people with or without disabilities. Pullin (2009) argues that there are certainly distinctions between *Inclusive design* and *Design for Special Needs*, because resonance can sometimes exist between the needs of people with a particular impairment and those of so-called '*able-bodied*' people, in particular circumstances. Blurring these boundaries could change business models, but then

⁴² <http://www.humancentereddesign.org/index.php?option=Content&Itemid=386> (Accessed 7th March 2012)

⁴³ <http://www.hhc.rca.ac.uk/resources/publications/include/2005/Include2005.pdf> (Accessed 28th November 2007)

demands a standard of design that a consumer market expects. Conversely, within populations of people with particular impairments, there may exist a diversity of attitudes toward their disability itself and about other issues. These cultural divisions should sometimes be respected and designed within, not across (Pullin, 2009:2-3).

Within populations of people with particular impairments, there may exist a diversity of attitudes toward their disability itself and about other issues. It is a fact that particular disabled or non-disabled people may have shared needs in particular circumstances, despite their differing abilities at other times. Furthermore, particular disabled and non-disabled people may have shared tastes and priorities that have nothing at all to do with their abilities. As Shildrick and Price (1996) argue, many disabled people are healthy, and many sick people are not disabled. Their purpose is to argue the notion of a fixed signifier, disabled or sick, for either bodies or for identity. The claim is that the body as abled/disabled has historicity and is constructed, not by once-and-for-all acts, nor yet by intentional processes, but through the constant reiteration of a set of norms. It is through such repetitive practice that the body as abled/disabled is both materialized and naturalized. In a reworking of the separation of self and other, there can be no understanding of, for example, able-bodied, unless there is already an implicit distinction being made that to be able-bodied is not to be disabled. Yet because able-bodied carries within it the trace of '*the other*' – a trace, which must be continually suppressed if able-bodied is to carry a delimited meaning - such closure is not possible. The spectre of '*the other*' always already haunts the selfsame: it is the empty wheelchair that generates 'dis-ease' in the fully mobile (Shildrick & Price, 1996:93-113). Stiker (1999) agrees that we should not demand of the disabled person that they resemble an able person.

Acceptance of and the greatest respect for difference are not to be expected from

⁴⁴ The term '*Design for Disability*' is used by Pullin, G. 2009. In: *Design meets Disability*. Cambridge, Mass.: MIT Press: p.2.

collective social structures but from immediate social surroundings (Stiker, 1999:194-195).

If there is a welcome change in designers' approach to disability from a medical to a social model, it follows that the role of design needs to change too, and therefore, the nature of design teams must change as well. Every design decision has the potential to include or exclude customers. *Inclusive design* emphasizes the contribution that understanding user diversity - variation in capabilities, needs, and aspirations - is giving shape to these decisions. If medical design wishes to success in the fashion area, it needs to appreciate that fashion often moves forward through extreme and even controversial work, and to welcome all influences within design for disability. It is more than attracting fashion designers to collaborate on designs for people with a disability or a deviant body, and bring their perspectives to both the practice and culture of inclusive fashion design. At times, this will expose cultural differences, but there will be healthy tensions, well-worth embracing and harnessing. Many designers still see *Design for Disability* as part of engineering and human factors disciplines, and perceive disability in terms of approaching legislation that threatens to compromise their creativity, rather than as a source of fresh perspectives that could catalyze new directions and enrich the whole of their work. Unfortunately, fashion designers, to date, are not part of the teams designing clothing for people with disabilities. Sometimes, this is an oversight, but at other times it stems from a deep cynicism (Pullin, 2009:45) about art school design disciplines. It may, actually be, as Pullin suggests (2009:64), more appropriate to involve designers, who are not experts in *Inclusive Design* at all, nor who even wish to become specialists in this particular field of design. Designs could celebrate a medical necessity, as in elegant and fashionable eyewear from Alain Mikli, or openly express functionality, as in Aimee Mullins's wooden hand-carved legs - bringing beauty to the world of disability and modifying '*stigma*' to '*fashion statement*'. Design processes need to

become more inclusive in several ways, involving not only disabled people themselves, but also a greater diversity of designers. If many designers are not engaging with disability, seeing only an encroaching legal obligation that will stifle their creativity, the way to change these attitudes is by more collaboration, not less.

Therefore, it is important to keep the word 'design' in *Design for Disability*. This might prove as challenging within design for disability as disability can be within a wider design community, but it is a challenge that both cultures need to rise to.

RESONANT DESIGN

The term '*Resonant Design*', used by Pullin (2009:93), is '*a design intended to address the needs of some people with a particular disability and other people without that disability, but perhaps finding themselves in particular circumstances*' (Pullin, 2009:93). *Resonant Design* is neither design just for able-bodied people, nor design for the whole population; nor even does it assume that everyone with a particular disability will have the same needs. It is something between these extremes, not as a compromise, but as a fundamental aspiration, while in order to appeal to both groups, such design would need to embody the design quality that a mainstream market demands (Pullin, 2009: 93-94).

4.4. Emerging Issues: Coping with Disability without Invisibility

Apparel is one possible market in which the fields of 'fashion' and 'disability' overlap. Clothes – besides providing warmth, protection and a creative outlet – can camouflage a figure variation, draw attention away from a variation, or create attractive illusions about a variation. It is the knowledge and ability of individuals to camouflage, direct attention, and create attractive illusions that makes them look attractive and beautiful. Fashionable clothing for people with non-standard body dimensions can become a positive image for the concept of disability achieved without invisibility. In such a case, fashion and

discretion are not opposites: fashion can be understated and discretion does not require invisibility. Perhaps fashion with its apparent preoccupation with an idealized human form is seen as having little to say about diversity and disability. Attempting 'camouflage' is not the best approach (e.g. invisible to the front view VELCRO closures sometimes can cause skin irritation, i.e. in open-back garments, when rubbing against the back of a wheelchair). In addition, there is something undermining about invisibility that could imply a lack of self-confidence or shame.

Since the Optional Protocol of the *Convention on the Rights of Persons with Disabilities* has been entered into force, in May 2008, disabled individuals have fewer legal barriers and more access to employment opportunities, transportation, and cultural excursions. Consequently, today more than ever before, they need attractive and comfortable clothes to wear while pursuing these opportunities⁴⁵. As an essential part of an individual's personal image, clothing can reveal a part of his/her personality, while being as stylish, sophisticated, and current as the work done by any designer, providing information that will allow the designer, seamstress, or tailor to address the disabled person's special clothing problems in an easy and organized way. Clothing for the disabled need not be clinical or unattractive – aesthetically pleasing clothing can adorn the disabled as well as the able-bodied, coping with their problems and educating the general public about paying attention to a group of individuals whose fashion needs have long been overlooked - not just by the design community but even by the individuals themselves.

From the research literature review and company publicity there appear to be two different strategies for coping with a body deformation or a disability: a *reticent* one, that attempts to compensate for it, as unobtrusively as possible, and an *assertive* one, that

⁴⁵ <http://www.politics.co.uk/reference/disability-discrimination> (Accessed 20th May 2012)

accepts that it is impossible to compensate for the deformity or the disability invisibly, and therefore, attempts to make the compensatory apparatus not only efficient, but also as aesthetically pleasing as possible.

This study, exploring issues at the intersection of human anatomy and fashion, follows an *assertive strategy* in designing for unique figures, because it is really regrettable, people who have suffered irreparable physical disfigurement should feel themselves constrained by society to conform to an able-bodied stereotype without having an able-bodied function.

4.5. New Perspectives point towards Customisation and Personalisation for the Individual

For all consumers, the choice of clothing products is governed by a number of different needs and restrictions, which can be classified as aesthetic, functional and availability requirements. Clothing is an area unjustifiably neglected in the context of *Inclusive design*, yet identified by disabled people as crucial to their feelings of self-esteem. The history of *Special Needs' Clothing* is that of the adaptation of existing styles for different conditions and body shapes with mixed results. However, the congruence of separate developments in international fashion, technical textiles, CAD/CAM/CIM production techniques, performance sportswear and extreme environment clothing and the possibility to embed technology promises the new advent of a new generation of '*smart wearables*'. Such clothing could combine mainstream fashion aesthetics with the functional advantages of new materials and appeal to consumers across the spectrum of age and ability, while technological innovations in both manufacturing and personal communications in the textile industry change the way manufacturers and retailers relate

to consumer demand (Anderson et al., 1997:24-25). Due to the shortening of product life cycles, the '*one size fits all*' principle is no longer applicable in the apparel industry.

In today's modern world, women's bespoke tailoring is more relevant than ever. With their financial status and lifestyle changes, women are indulging their tastes for finer things with bespoke tailoring, while the demand requires smaller batch sizes since consumers want more variety in their selection of apparel. Evidently, the industry needs a breakthrough in apparel manufacturing to accommodate this change (Bae, & Plumlee, 2005:4:4).

Meanwhile, several companies are already offering their customers mass customized products of various kinds. Mass customisation is a hybrid of mass production and customisation. The concept was first conceived by Stan Davis in his book *Future Perfect* (Davis, 1987: 148) and was further developed by Joseph Pine in his book *Mass Customization - The New Frontier in Business Competition* (Pine, 1993), but it was not until the beginning of the 21st century that business models around mass customisation emerged, developed to reflect customer personalisation toward merchandise with the speed of mass production. Via technologies such as body scanning, garment modelling, digital pattern design, garment simulation and information technology, the customers configure their garment by selecting from modules (customers' own measurements, fabrics, colours, style elements and trims) in fixed systems to receive their own designed version. This increases the probability of mass customization being adopted as an acceptable business paradigm (Istook, 2002:61).

Mouwitz et al. (2009) argue that in customized clothing, there is normally a limited selection of silhouettes. The shapes in general cannot be changed but individuals may have some options to change details, to load a print or to add embroidery or some other decoration. Still the garments look similar to mass-produced clothes. The amount of

available colours, is restricted by, and connected both to the style and the selection of fabrics. In some companies the selection of fabrics is huge, but within the group of fabrics, which are already used on similar mass produced garments.

Despite mass customization in the service context, in modern society, is in an emerging stage (Piller & Tseng, 2010:592), mass customization in the apparel industry today can be regarded as an established field, although manufacturers have been understandably reluctant to abandon their previous production practices to completely re-engineer their businesses on new patternmaking methods, in order to meet their customers needs. A fundamental approach in *mass customization* is technology to match an *existing assortment* of garments to an individual profile of one consumer, helping customers to better navigate the existing choice. The apparel industry is being a forerunner of this application of mass customization, having the potential to address all three possible dimensions of customization: fit, functionality and aesthetic design and, with the advent of new and enabling technologies, the opportunity to bring mass customization to fruition.

Many retailers in the US and Europe offer, in the last decade, custom clothing using these new technologies, although product types are confined to classic styles such as jeans, shirts and tailored suits. A UK company called '*Bodymetrics*' has now four custom clothing units offering digital personalized jeans – two in London (*Selfridges and New Look*), one in Dusseldorf (*Karstadt*) and one in Palo Alto, USA (*Bloomingdale's*)⁴⁶.

Precise measurements of individual consumers are required to customise apparel products. The most highly developed measurement device measures the entire body three-dimensionally using a laser. The consumer is scanned while wearing his/her street clothes, while about a minute later, a printout of the image is made and the measurement information is stored in a central database or on a smart card, used by the

⁴⁶ <http://www.bodymetrics.com/location.php> (Accessed 2nd March 2014)

consumer, in order to select his/her garment of choice and the pattern is adjusted automatically to fit the measurements made in the store (Lee et al., 2002:138-146). Moreover, apparel manufacturers have begun to try JIT (Just-In-Time) or QR (Quick Response) concepts to eliminate excess inventory, long-lead time, and low quality in traditional manufacturing systems (Black & Chen, 1995:17-35), investing in computer systems to control design, cutting, embroidery, and sewing information (Taylor, 1990; Kalman, 1997:12-14).

Calhoun, Lyman-Clarke and Ashdown (2007) studied the personalization in fashion retail over the Internet, comparing a match-to-order system, where a standard good is matched to the personal profile of a consumer, with a make-to-order system where the product is produced on demand based on the personal consumer profile. This revealed how personalized online recommendation systems can improve consumer confidence in purchasing, and ultimately boosts sales (Piller & Tseng, 2010:594). With these earlier advancements in manufacturing technology, apparel industries found new niche markets for the made-to-measure garment (Harris et al., 1992:56-61). Now, rather than just niche markets, customisation may become a broad trend for apparel industry production and retail (Burns & Bryant, 1997).

Mass customisation is expected to replace *Mass Production* in the 21st century, as it is regarded as a new paradigm, based on creating variety and customisation through flexibility and responsiveness and is perhaps, an application that combines the '*craft*' era with the '*mass production*' era.

According to Kurt Salmon Associates' 1997 Annual Consumer Outlook Survey, 36% of consumers are willing to pay up to 15% more for customised apparel and footwear, and will wait up to three weeks to receive their customized product (Apparel Industry:

Consumer customization, 1998)⁴⁷. This report, however, does not negate the values of low cost and fast delivery in the consumer market. Most of today's consumers require high-quality customized products at low prices with faster delivery, while this sort of consumer interest had lead to the concept of mass customisation in the late 1980's (Lee & Chen, 1999-2000:1-8).

According to Mouwitz et al. (2009), both designers and amateurs could use *personalised customisation*, which is the utopian way to produce one-off garments. Unlimited design means the silhouette and lines can be changed, as well as the quality, structure and colour, addition of images, photos, patterns or personalized design and trimmings. Somehow we are back to the basics, when the designer works from a blank piece of paper and almost any garment is possible, however:

- Is open design really possible for garments?
- Is the market big enough?

Several of the components required to make '*mass-personalised*' clothes already exist but are spread over big areas. Nobody today has all the knowledge of producing such a system on their own. By combining production techniques for mass production with information technology, a market for '*mass-customised*' products have been created and is today increasing. The next step is to take it beyond *customisation* into *personalisation for the individual*, where each garment is designed to fit each customer's specific individual needs and wants.

It is believed that this can be achieved by taking knowledge from product development and combine these with mass production thinking (Mouwitz *et al.*, 2009). Most factories are focused on mass production, which means it is rather difficult for them to produce

⁴⁷ Apparel industry: Consumer customization. (1998). In:
<http://www.aimagazine.com/archives/598/mastor9.html> (Accessed 13th November 2011)

one-off garments. However, every new season, designers of clothing have developed new styles in the product development and design departments. The first trial of a new product idea is normally made as a one piece, called *first samples*. There are similarities from preparing the first samples for mass products, which might be applicable when the new generation wants to fulfil their designer dreams and buy their own designs, produced by tomorrow's professional retailers and producers. The knowledge from this *first sample development* phase can be combined with production methods for traditional garments made for masses and the combination could be a solution for producing unique garments that goes beyond *Mass Customization* into *Personalization for the Individual*. This kind of personalization carries huge emotional significance, enriching our lives. It is a far cry from the mass customization that allows a consumer to choose one of fixed sets of alternatives, but has little or no real personal relevance and little or no emotional value, which is a worthy goal of design! (Norman, 2004:221).

As Mouwitz *et al.* (2009) point out, there is a huge market of '*individualists*', longing to make their own truly designed items who are not satisfied with only choosing from a library of fixed modules and of-the-shelf decorations. These customers want to change the garments in rather extreme ways, changing the core values of the products, in order to implement their own personal values.

Therefore, a new approach in apparel design, as a discipline of broader design, has to follow a creative process, which concerns pattern design and innovative clothing solutions, focusing on the need for new pattern design methods, based on a better understanding of different body configurations, that could benefit the clothing market for women with diverse body figures.

Chapter 5

The Need for Clothing designed to conform to Non-standard Body Types applying an ‘Aesthetic’ and an ‘Ethical’ approach in User-Centred Design

Dressing requires finding clothes that fit our bodies and the way we look, as well as the society and occasions we are part of (Entwistle 2000:8). The fit of a garment contributes to the confidence and comfort of the wearer (Alexander *et al*, 2005:52; Klepp, 2008:13), while it is a complex interplay between physical and psychological structures, which is critical, in order for one to appear well dressed.

The attributes that make a garment personal are precisely those that cannot be designed ahead of time, especially in mass production. Manufacturers try - many provide customisation services, while others allow special orders and specifications or provide a flexible product that, once purchased, can be tuned and tailored by the people who use it. However, garments do not become personal because we have selected some alternatives from a catalogue of choices. To make something personal means expressing some sense of ownership, of pride. It means to have some individualistic touch.

There is a tension between satisfying our needs by purchasing a ready-made garment versus making it on our own. Most of the time we are unable to make up the garments we need, for we lack the tools and expertise, not to mention the time. But when we buy someone else's garment, seldom does it fit our precise requirements. In manufactured design, clothes are configured and made according to particular specifications that many users find irrelevant. Ready-made, purchased clothing, for example, seldom fit each individual perfectly, although they might be close enough to be satisfactory. Fortunately,

each individual is free to buy different kinds of clothes and then combine them in whatever way works best for them, reflecting their own personality.

The various ways of dealing with this problem are, either to live with a mass-produced garment and benefit from its lower cost, to customise it, to modify it - which is probably the favourite and most widely followed method to make purchased garments into personal ones, all over the world (Norman, 2004:222-224) - to design and construct it on our own or to have it manufactured-to-order.

5.1. Garments Custom-Made, Altered, or Made-To-Measure to fit Individuals with divergent body figures, including Individuals affected by Scoliosis

Although, today, there is a plethora of apparel products offered in the market, certain individuals still find it difficult to achieve a good fit in their clothes. Normally, such individuals should consider having their clothes custom-made for them – at least some of them. It may be the only way for obtaining the fit and quality they want, due to the fact that with custom-made clothes the design or pattern is altered to their exact measurements.

A major issue for having one's clothes custom-made is, usually, their high cost. They may cost no more than what one would pay for good-quality ready-made clothes plus alterations – or sometimes less. Normally, however, the cost can be somewhat more due to the fact that one is paying for a specialized service and one-of-a-kind garments. Other factors also enter in, such as the area of the country where one lives in, the state of the local economy, along with the experience and reputation of the professional.

Moreover, having clothes custom cut and sewn takes *time* – more time than it usually takes to go to the store and buy something off the rack. The time is well spent, however,

if the clothes fit. More complicated styles take more fittings. Custom clothes are better not rushed - at least two weeks to a month if possible, depending on the garment style and dressmaker's schedule should be allowed for obtaining the finished garment. Unlike retail, an item cannot be taken back if it doesn't meet the intended individual's needs. Generally, custom-made clothes rely on comparing the pattern with body measurements. An ease allowance is added to the measurements at points where the body moves or expands. After that, the pattern is compared with the corresponding body-plus-ease measurement.

'Alteration' is the process of changing particular parts of a garment to fit a particular individual. The goal with altering patterns is to achieve well-fitting garments for individuals with non-standard body shapes and types, while with minor adjustments the garment can look as if it were custom-made. Successful alterations depend on knowing when to alter and when not to alter, where to begin and how to proceed.

There are two types of size alterations:

- The first type includes alterations made when body measurements differ from standard measurements, such as changing the length of a basic skirt, pant or sleeve, taking in the waist, letting out the hip and thigh area, or shortening crotch depth in trousers.
- The second type includes alterations on curved areas that can't be measured with a tape, such as altering for a sway back, flat buttocks, or raising the crotch curve.

The only way to analyze the fit and need for alteration is to see how the garment hangs and pulls on the intended individual's body. In many cases, the alteration cannot be done because the fabric has already been cut. Hence, not all garments, or all areas on a

garment can be altered successfully, while if an alteration seems impossible, it should be accepted, i.e. no specialist in garment alterations can take in a size-16 piece of clothing to fit a size-12 body figure, or let out a size-8 piece of clothing to fit a size-14 bone-frame.

The most important standard that should be met when a garment is to be altered for people who have figure variations that differ from one side of their body to the other – i.e. have an asymmetrical figure, due to scoliosis – is to retain the original style of the garment, while the alteration procedure must solve the fitting problem that results because of the figure variation in question. This procedure should not change something that wasn't meant to change. The straight grain-line arrow must be positioned the same as before the alteration so the fabric hangs or drapes properly. Another significant aspect, should be that the centre-front and centre-back seam-lines or fold-lines on a basic pattern should be kept straight, while the seam-lines that intersect the centre front, centre back, or sides should lie at right angles on a basic pattern. Moreover, the hem corners on basic pattern pieces should form right angles, and if the pattern lies flat before an alteration, then it should lie smooth and flat after the alteration. Overall, there should not be any puckers or wrinkles after the alteration is completed.

Nevertheless, educators in patternmaking, instruct their students the correct way to achieve garment fit, which is to create a pattern with the desired fit from the beginning, based on individual body measurements, and not to alter already existing patterns (Zamkoff & Price, 1997; Joseph-Armstrong, 2000).

Today, Made-To-Measure garments, normally, are generated via an already established basic pattern block, while the adaptations needed, in order to 'accommodate' the specific body, for which the order is being placed, are added to this basic pattern block. After

that, the unique garment derived from this '*adapted*' basic pattern block is suitable for that specific individual.

The final Made-To-Measure garment has to be in total harmony with the individual's silhouette and shape. For many people, any distinctive body features or any body deformations should not be more visible than necessary. It is the actual interplay between the body figure and the garment's final shape that gives a well-fitting dress.

5.2. The Need for Apparel Pattern Design to conform to Non-standard body figures, such as figures affected by Scoliosis

According to Hernandez (2000), Frost (1987:30) had developed a method for creating basic pattern blocks, for handicapped individuals, which started by measuring the deformed body, and then constructing the suitable basic block. The measurements were taken on both right and left side of the body, in order to register the difference between the two body halves. A mean value was then calculated and used for the construction of a symmetrical pattern. With the symmetrical pattern, as a base, the differences on right and left side were applied by increasing/decreasing the pattern at appropriate places (Figure 5.1 – see Appendix A, Hernandez, 2000:113). This 'basic pattern' construction method, used by Frost (1987:30), has been evaluated in previous studies and shown to be very time-consuming (Thorén, 1994: in Hernandez, 2000:30-31).

By contrast, Hernandez (2000) suggested that instead of designing the individual block pattern from scratch, a standard block could be altered, in order to create the individual pattern 'block', owing to the fact that when using a basic pattern block as a starting point, the proportions of the designed garment are already evaluated. The individual proportions, of course, have to be added, but they should just make the garment

harmonize with the body figure, not change the design. Moreover, extra knowledge is needed, in order to design accurately an individual basic block for such divergent bodies, from scratch (Hernandez, 2000:32).

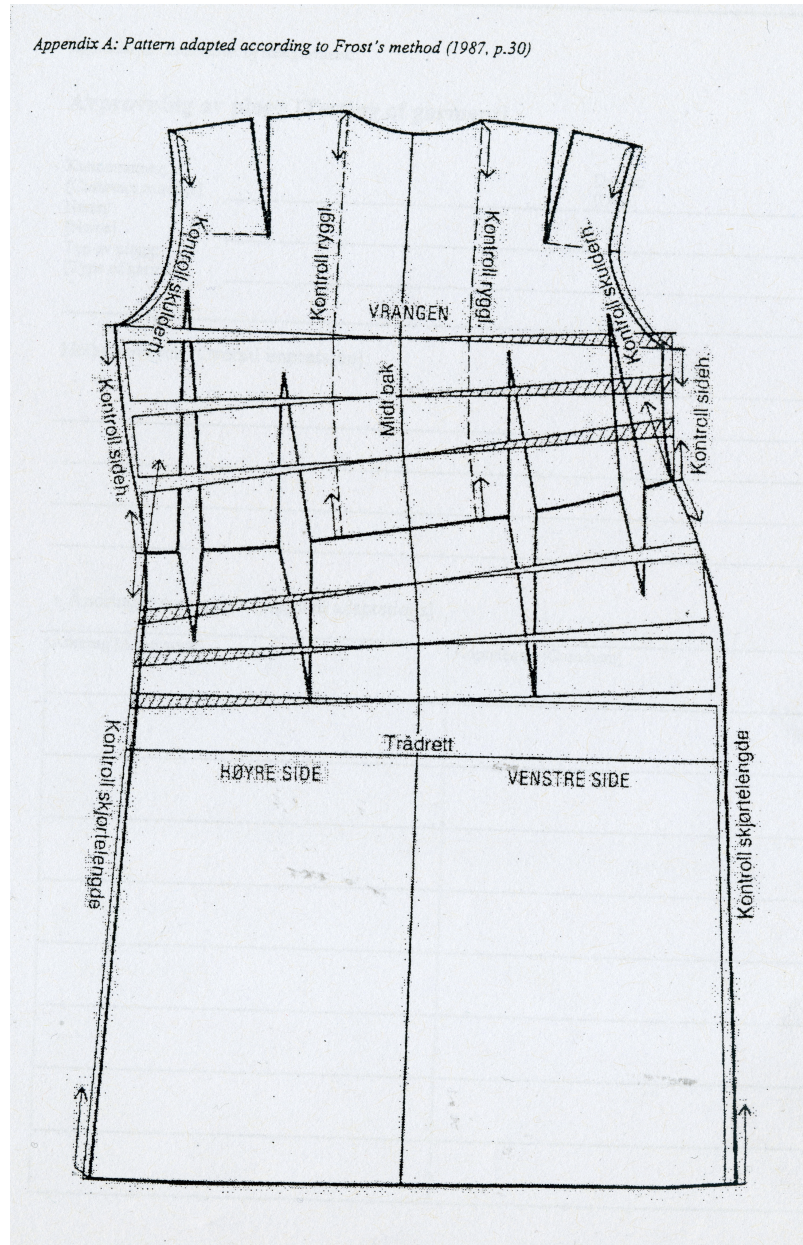


Figure 5.1. The differences on right/left side are applied by increasing/decreasing the pattern at appropriate places (Frost's method)

More recently, Chase and Quinn (2003:84-86) suggested certain pattern alterations for accommodating a body with scoliosis, altering the front and back bodice block, as described in Figure 5.2. Using the measurement chart, the difference in length between the higher shoulder (to neck base) over bust point to waist and the lower shoulder (to neck base) over bust point to waist⁴⁸ (Chase & Quinn, 2003:76) is determined, and a line, joining the underarm point on the higher shoulder side to approximately midway along the side seam in the opposite side, is drawn and then slashed. After that, the pattern is appropriately overlapped in the lower side and spread on the higher side, while the edge of the pattern piece is redrawn, so that a smooth line is achieved (Figure 5.2).

Nevertheless, all the above patternmaking methods represent a pattern design approach for '*divergent*' or '*asymmetric*' human bodies (i.e. bodies of females with scoliosis), whereby, at first, a basic symmetric block is created, and the actual pattern for the specific individual is designed after a few adaptations. This is, indeed, a far too much time-consuming procedure, not to mention that the result will likely not be as precise, as if the actual pattern for the specific individual was designed from scratch as an asymmetric pattern that could not be '*mirrored*' vertically, at the Centre Front or Centre Back.

Following a quite *reticent strategy* when designing Made-To Measure clothes for individuals with body deformations, Hernandez (2000:40) argues that within this interplay, certain accessories can be used so as to '*smooth*' the difference between the disfigured body and the garment. If, for instance, an extra shoulder pad is used in order to compensate for a 'lowered' shoulder, the garment will look more symmetrical, while it will still harmonize with the silhouette of the body, providing good fit and wear comfort, as

⁴⁸ This measurement is called the '*Full Bodice Length*' measurement (*3a, 3b, 3c, 3d*), in this research (see Chapter 7.3.2:233 – Table 7.1)

fit is a subjective term that describes how well a garment conforms to the expected shape on a person's body (Istook, 2002:72).

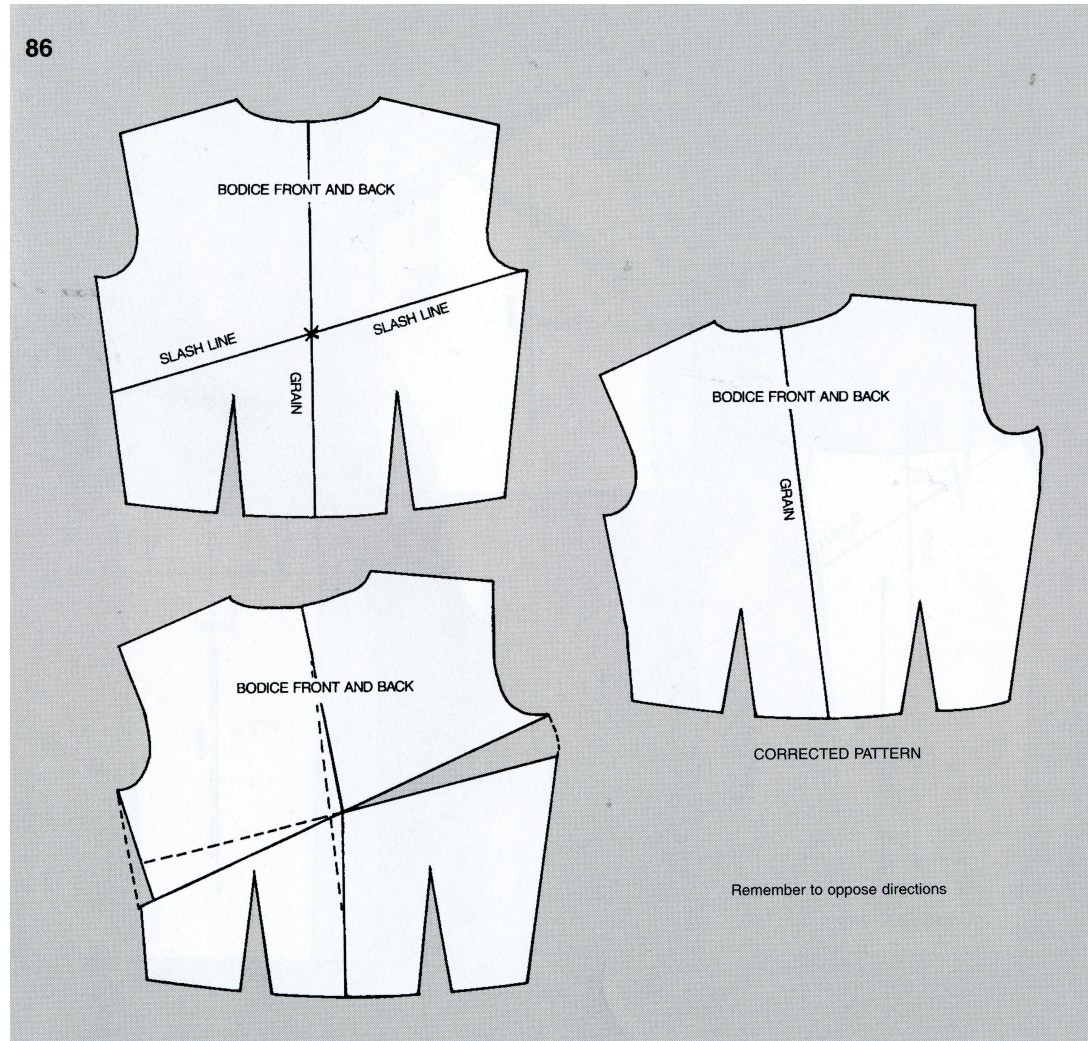


Figure 5.2. The differences on right/left side are applied by increasing/decreasing the pattern at appropriate places (Chase & Quinn's method)

A well-fitting garment requires a correctly designed pattern, and of course, the appropriate garment style for the body wearing it. Finding a balance between the body figure, the designed style and the necessary adaptations for accommodating any deformities leads to a perfect-fitting individual pattern. When designing individual patterns for individuals with severe deformities, the garments should have the

appropriate style lines, in order to accommodate these deformities. These style lines are crucial not only for the fit, but also for the hang and appearance of the garment.

In addition, individuals with scoliosis and prominent disfigurement, usually, have balance and fit problems with standard garments between the left and the right side, due to the fact that the projecting body part does not fit inside symmetrical conventional retail clothing: the garments pull up at the projection's side and are tight widthways. Usually such individuals have to select a larger sized garment, while as Hernandez (2000) points out, the projecting body part might fit into the garment but the larger size makes the garment too big in other areas. Therefore, adaptations are needed in order to alter the pattern, increasing its size over the prominent body part without increasing the size of the whole garment. The alteration of the pattern can be made either lengthways, widthways, or with a combination of both (Hernandez, 2000:10-11). Hence, for such individuals, a few *extra measurements* need to be taken, in order to determine the scoliotic curve's size and its exact location.

Following a more *assertive strategy*, I believe that any adaptations or adjustments have to be used, finding a balance between '*camouflaging*' the deformity and making up a garment that harmonizes perfectly with the individual's silhouette. Sometimes, the left and right side of an individual's body differ a lot, in terms of measurement values, and this can lead to a down-slanting hemline, or uncomfortable wrinkles and gathers of fabric. In such a case, the garment needs to be adjusted, in order to obtain a straight hemline. In any case, the goal should be to keep the initial proportions and style of the garment, while the garment should conform to the body's asymmetry.

A good fit requires enough fabric to accommodate the prominent part area, plus necessary amounts of fitting ease – extra fabric beyond the body measurement adequate for a comfortable fit and movement. The fabric should hang smoothly over the

body and meet basic fitting standards, i.e. how fabric conforms to the body, if the grain-line is distorted, and so on. A good fit also eliminates the gaps and wrinkles that emphasize possible figure variations and fitting problems. One of the easiest and most effective ways to improve or enhance one's appearance is to achieve a very good fit in their clothes. To achieve harmony and unity in appearance, clothing must also fit other factors of personal style, such as values, personality traits, and personal colouring, as well as lifestyle – so forming the *intangible* elements of design. From this point of view, a good fit involves more than just the figure.

Today's clothing market is not adapted for people with unusual body dimensions and/or different kinds of functional impairments. A method of user-oriented product development could possibly solve their problem when, to date, clothing producers make special designs for disabled people, e.g. for wheel chair users, and the distribution is often by mail order. Nevertheless, many disabled people feel that these special garments still emphasise their disability, in a non-aesthetical way, and would prefer to take the trouble to buy their clothing in conventional retail stores with a much larger choice and make adaptations conforming to their needs.

Their clothing requirements are very much dependent on their impairment not only regarding the fit and function of the clothing, but also regarding shopping and service in the stores. In combination with other developments in *Information Technology* (IT) it could be possible to synthesise a new system where the manufacturers and retailers of clothing can co-operate in order to provide service to such users (Thorén, 1996:389-396). The solution to the clothing dilemma of the disabled, however, does not lie in coming with, adapting, or altering already purchased clothing, due to the fact that clothing produced with standard patterns **do not** fit persons with deviating body dimensions and the patterns have to be altered according to individual body dimensions.

Hence, there are many individuals within the categories elderly, impaired, and/or disabled who have exceptional problems in finding suitable clothes and need specially designed clothing. There are, however, several reasons why the possibilities of this choice are restricted.

Compared to the majority of the population, the special requirements of disabled or elderly people are diverse, and the local demand for special products is often limited. Retail stores and fitting rooms are designed for people who are walking without restrictions, and clothing is constructed for people with standard body dimensions and configurations. Reduced or impaired mobility could be the result of spinal deformity, or spinal cord injury. Nevertheless, two people with spinal deformities will rarely have identical body configurations. Therefore, the common factor for a clothing study is not a particular deformity (as scoliosis), but the physical changes that are the result of that deformity. Obviously, clothing for all spine-injured people cannot be the same. Garments must be designed to answer the problems caused by the disease or injury. Each problem requires a unique design solution and should be treated accordingly. When we consider the functionality of a garment, we focus on the physical requirements in dressing that are the result of a particular disability. Functionality should always be in relation to the individual's particular disability and the requirements this disability places on clothing. Furthermore, the art of dressing and undressing oneself requires coordination of sight, sensation, dexterity, balance, and muscular strength. Since many physical disabilities limit coordination, the ability to dress oneself may be severely limited. Pain, fatigue, fear, agitation, and frustration also add to the individual's inability to perform motions we often take for granted. The inability to dress and undress can rob an individual with a non-standard body configuration of necessary feelings of satisfaction, pride, and self-worth. And even though fit, colour, and comfort are important features to consider in the design

of a garment, the problem of ease in dressing and undressing is often of greatest importance (Chase & Quinn, 2003:61-62). Chase & Quinn (2003:8) suggest that whether the designer of this clothing is an accomplished professional or a skilled home sewer, the goal is the same: the '*marriage of function and aesthetics*', the production of functional, yet appealing garments.

5.3 Applying an 'aesthetic' and an 'ethical' dimension in User-Centred Design

Human factors and ergonomics have long established their goals of enhancing the safety, comfort, productivity, and ease-of-use of products and systems (Wickens et al., 1998) and have made great strides toward achieving these goals. Although there have been calls for the expansion of the research scope of human factors to include emotional aspects of design and there have been some endeavours toward that direction (Jordan, 1998:23-33), aesthetics has not generally been regarded as one of the central topics of ergonomics research (Liu, 2003: 1273-1292).

As Liu (2003) points out, a broader view of *Ergonomics* should include an *aesthetic* dimension and an *ethical* dimension, which would help us realise that aesthetic ergonomics is not just about tangible products made to sell or consume; it is also about intangible systems, jobs, and environments (Liu, 2003:1274-1275). The aesthetic and the ethical dimensions provide us a broader framework with which we can categorize and understand past, current, and future work systems and products.

5.3.1. The Role of 'Aesthetics' in Functional Apparel Design

In the Second Edition of her book, *Clothing: The Portable Environment*, Susan Watkins (1995) outlines the design process for functional apparel. Functional clothing is

a portable environment that protects the body, increases health and safety, improves a worker's job efficiency and/or increases body function. Functional clothing has specific requirements for fabric, lining, and accessories and is created for a select group of users with particular needs that arise due to interaction with the environment. Any garment can be placed along the Aesthetic-Functional Continuum, as developed by May-Plumlee & Pittman (2002:1-10). This is because all apparel items must meet minimal **functional** and **aesthetic** requirements, such as allowing some freedom of movement, selecting the appropriate colour or texture, etc.

According to Watkins (1995), the design process for functional apparel is broken down into four phases: *Analysis*, *Design*, *Implementation* and *Deployment*, with suggested activities for each phase: The *analysis stage* needs to include an investigation of the design setting (the environment), individuals associated with the project, and materials that are available for use in the design setting. During the *Design Phase*, designers start to brainstorm design concepts and metaphors, develop screen flow and navigation models, begin design with paper and pencil, create low-fidelity prototypes, as well as tests on low-fidelity prototypes, create high-fidelity detailed design, redo usability tests, document standards and guidelines and create a design specification. During the *Implementation Phase*, designers work closely with delivery team as design is implemented and conduct usability testing as soon as possible. According to Watkins (1995), evaluation techniques include observation, interview, questionnaires, laboratory testing, etc. *Implementation* is the point where the product evolves from the process, and the chosen ideas are put to work. Finally, during the *Deployment Phase*, designers use surveys to get user feedback, conduct field studies to get info about actual use and check the objectives using usability testing.⁴⁹

⁴⁹ http://www.upassoc.org/usability_resources/about_usability/what_is_ucd.html (Accessed 7th March 2012)

It is quite noticeable that '*usability testing*' appears several times throughout the design process, from the first phase to the last, owing to the fact that providing a great user experience is an ongoing process. This is also the core of *User-Centred Design* (UCD), which, as a design philosophy and a process in which the needs, wants, and limitations of end users of a product are given extensive attention, at each stage of the design process, is not just adding an extra feature to a product to meet the perceived needs of a user.⁵⁰

Aesthetics and appearance have always played a major role in design. This role was increased during the mid 20th century, when the design concept started to imply, not only the look and appearance of a product, but also the process through which the product was developed. According to Dobbers & Strannegard (2005:324-336), products were not bought for their own sake, but for their capacities as lifestyle carriers.

Later, in the 1990s, the marketing and consumption focus became increasingly immaterial, due to the increased interest in design and the multitude of meanings that the concept encompassed. The word '*design*' has a wider meaning among designers and product developers than for the general customer. Thus, in order to understand the role of design, it is necessary to examine the role of the design concept, the design process, and the relation between design and consumption (Dobbers & Strannegard, 2005:324-336).

The role of aesthetics and appearance in design is bound to increase dramatically in the 21st century as the society and market become more sophisticated and the manufacturing technologies become further developed. To compete and succeed in the market place, manufacturers will have to make products more reliable and physically qualified, while paying more attention to the appearance and aesthetic dimension of their products. Today, more and more corporations are turning to the production of images

⁵⁰ http://tiresias.org/reports/projects.htm#inclusive_design (Accessed 23rd September 2008)

instead of focusing on the production of material objects (Lash & Urry, 1994). The image is the key to understanding how we make sense of the world. An aesthetic image serves as a stimulus, a sign or a representation that drives cognition, interpretation and preference (Zaltman, 2002). Moreover, the influence of images may affect the way new information and experiences are interpreted (Lash & Urry, 1994). Western societies are becoming increasingly aestheticized, while companies' marketing efforts have led consumers to constantly search for new fashions, new styles, new sensations and new experiences (Featherstone, 1991). Currently, in academic settings and scholarly discourse, the use of the term '*aesthetics*' is primarily centred at the history of art and the criticism of the arts (Honderich 1995). Encouragingly, a number of empirical studies of aesthetic concepts have appeared that can be found both inside and outside of the domain of arts (Langlois and Roggman 1990:115-121). Both philosophical discussions and empirical studies agree that aesthetic responses and appraisals are not limited to *beauty judgements*, while there is rather a whole range of aesthetic notions such as '*the sublime*', '*the beautiful*', '*the pretty*', '*the cool*', '*the fashionable*', '*the funky*', '*the ugly*', and '*the tragic*' (Honderich 1995; Devereaux 1997). The subject of aesthetics relies on the fact that beauty is a necessary ingredient in our lives. Creating, thus, an aesthetically pleasing object, whether it ultimately hangs on a museum wall or is worn to work each day, should be the goal of every designer.

Design is becoming a central feature for companies to become competitive, and, meanwhile, a means for consumers to express themselves (Dobbers & Strannegard, 2005:324-336), as they not only dress to stay warm or dry, but also to express identities, socialize and feel happy (Meyer, 2001:317-330). Therefore, a customised pattern design system and methods based on non-standard body dimensions, resulting in fashionable

clothing of high aesthetic values, conforming to scoliosis, could give individuals with scoliosis back the value that was denied them, in terms of conformity and normality.

5.3.2. Adding an 'Ethical' Dimension to Aesthetic and Functional Design

Furthermore, design decisions may have **ethical** implications. Hence, it is important to incorporate the *ethical* dimension, explicitly and systematically, in ergonomics research and practice. The ethical imperative and the moral claims are nearly non-existent in the contemporary style ideal. Taste, today, is a lot more about *aesthetics* and less about *ethics* (Dobbers & Strannegard, 2005:324-336). Only recently, systematic work has started to examine the ethical implications of product design from the human factors point of view (Liu, 2003:1293-1305).

As Liu (2003) points out, in order to incorporate *aesthetics* and *ethics* in human factors research and practice, going beyond philosophical debates and intuitive judgments, there is a need for developing theoretical and methodological foundations for systematic and scientific investigations of the aesthetic and ethic issues in product and work design. There is a need for developing comprehensive, quantitative, and rigorous understanding of the concepts involved, a need for developing measurement and evaluation methods, a need for identifying the qualitative and quantitative relations between an individual's aesthetic or ethic judgments and design parameters, and a need for developing theoretical frameworks for integrating and interpreting research findings (Liu, 2003:1295-1296).

On the one hand, design is about making things more useful, easier to use, more efficient, or simply more pleasurable. By its nature, it tends to be used commercially because it is a powerful tool in making a message communicate more effectively or making products more compelling for those that actually use them.

On the other hand, when discussing design, aesthetics is often the first thing to come to mind, while it is actually how a product functions that designers should be concerned with, in the first place. Meanwhile, it is scientifically proven that attractive things are perceived to work better (Lidwell *et al.*, 2010:26-29), and although it is still an issue of debate in philosophy about whether aesthetic response is independent of utilitarian value judgments and ethic judgments, more and more philosophers have started to examine the moral functions of art and the moral responsibilities of the artist. Mary Devereaux (1997) argues that a central concern of aesthetics today is the relation of aesthetics and moral value:

'We might say, with slight exaggeration, that we are experiencing an ethical turn in aesthetics and an aesthetic turn in ethics' (Devereaux, 1997).

An interesting question, at this point, would be:

- How could aesthetics affect how easy something is to use?

The answer to this intriguing question has to do with human emotions. According to Norman (2004) emotions change the way the human mind solves problems – the emotional system changes how the cognitive system operates. So, if aesthetics would change the human emotional state, the mystery could be explained. Modern work and scientists support that emotions play a critical role in daily lives, helping assess situations as good, bad, safe or dangerous. For instance, positive emotions are as important as negative – positive emotions are critical to learning, curiosity and creative thought, and today research is turning toward this dimension (Norman, 2004:19).

Psychologist Alice Isen and her colleagues have shown that being happy broadens the thought processes and facilitates creative thinking. They also discovered that when people feel good, they are better at brainstorming, or at examining multiple alternatives

and their thought processes expand, becoming more creative, more imaginative. On the contrary, when people are anxious they tend to narrow their thought processes, concentrating upon aspects directly relevant to their problem (Isen, 2008:548-573). Such findings suggest the role of aesthetics in product design: attractive things make people feel good, which in turn makes them think more creatively. Hence, a product is made easier to use, simply by making it easier for people to find solutions to the problems they encounter. People who are in a positive emotional state are apt to look around for alternative approaches, which is very likely to lead to a satisfying end.

A crucial aspect of the relation between **aesthetics** and **morality**, however, emerges when the newly designed product is accepted, where acceptance amounts to compliance with agreed standards and conventions.

Therefore, questions like:

- Will this design be appealing and attractive to the potential buyers or users?
- Is the new product good for the users and acceptable to other people and society?

and other similar questions, should be constantly in the minds of system and product designers in making design decisions.

The aesthetic appearance of a product has a large bearing on its potential market share, and the ethical implications or consequences of a product can have significant societal implications and *make* or *break* the moral reputation of the designer or manufacturer. Overall, although designers and decision-makers deal with *aesthetic* and *ethical* issues, constantly in their practice, they often make aesthetic and ethical decisions on the basis of their gut-feeling and intuitive judgments (Liu, 2003:1293-1305).

Hence, this research study emphasises the need for fashion and pattern designers to try 'including' the diverse female body types (i.e. bodies with scoliosis) into the broader discipline of pattern design, investigating into new pattern design methods, in order to provide apparel with a better fit.

5.4. The Design Factors that will enable Clothing Companies to become more *Inclusive*, concerning *tangible* and *intangible* needs

In the case of *Clothing for Special Needs*, it can be difficult for the disabled customer to design their individual garment. They might have an idea of how they want the look of the particular design of a certain garment but to translate that into an actual garment in a specific fabric or material requires some skills, which only a good designer can provide. The design elements and principles required to build up garments are described as *silhouette*, *line* and *texture* (Jones, 2002). The meaning of *silhouette* is shape and volume, while *line* is normally the cuttings or the lines of a garment and *texture* refers to the structure and the parameters of a material. Jones (2002) states that the suitability of a fabric for a fashion design comes from a combination of yarn, construction, texture, colour, pattern etc., as well as additional performance factors as warmth, stain-resistance, etc. The designer must have knowledge of how a fabric will behave both practically and visually. Many designers start by finding a nice fabric and make a suitable garment out of it, but the process can also work reversed. It is a fact that the fabric sets the possibilities and the limits of the styling elements. *Colour* is another very important parameter with strong impact for garment retailing. Jones (2002) claims that several design principles, as *repetition*, *rhythm*, *graduation*, *radiation*, *contrast*, *harmony*, *balance* and *proportion* will affect the elements and the overall design.

Fashion designers should be able to identify the above design elements and principles, trying also to incorporate the '*ethical*' dimension in their designs, enabling fashion and clothing companies to become more inclusive along two different aspects of fashion analysis – *trends, attitudes, values* and *lifestyle* towards the *body*, its *shape* and *sensory factors* – addressing two major questions:

- How do we use engineering and scientific methods to study aesthetics and ethical concepts in clothing design?

And
- How do we incorporate engineering and scientific methods in the aesthetic / ethical design and evaluation process (beyond the designer's intuitions and trend analyzer's 'hunches')?

This is a *dual-process* research methodology for '*engineering aesthetics*', developed by Liu (2003:1303), having as a goal to employ scientific, engineering, and mathematical methods, in order to systematically identify and quantify the roles of aesthetic and ethical factors in system design. This dual-process methodology, addresses these two questions *with multi-dimensional* construct analysis (the top-down process) and *psycho-physical* analysis (the bottom-up process) (Liu, 2003:1303).

According to the dual-process methodology, we must not only identify the important factors and examine their relative importance, but also study these factors at a local, psycho-physical level. A potential benefit of this methodology is that it offers a systematic, step-by-step process to follow, which may help a research team to plan and coordinate its research activities. It also helps researchers to achieve a quantitative understanding of the aesthetic and ethical issues involved. The proposed methodology is an integration of a large number of existing methods that have been developed and

applied in diverse areas. It offers an integrated framework for applying existing methods to a new problem in a systematic manner (Liu, 2003:1286-1289).

For example, when using aesthetic judgments of a skirt's fit, the *top-down process* (multidimensional construct analysis) asks questions such as: What attributes affect a person's judgment of a skirt's fit? How does a wearer feel in the skirt? Is it the skirt's shape? Is it the skirt's size? Is it the darts/pleats concentration in the design? How important is each attribute and how do they relate to each other?

On the other hand, the *bottom-up* process asks questions such as: Suppose we know how a wearer feels in the skirt is important, then, how sensitive are the wearers in judging variations in skirt fit? For example, suppose the most preferred wearer is a size XS for a specific skirt - selling this skirt only in size XS can be very costly for a clothing department store, because potential wearers of other sizes will not be able to fit properly in that specific skirt, resulting, thus, in customer loss. Thus, there is a need for a psycho-physical study to establish the threshold difference of wearers' judgments on the skirt fit.

The supply of clothing products may be also dependent on *location*: Choice and availability is greater in large cities than in rural areas. For persons with limited or without mobility at all, shopping in conventional retail stores can be impossible, and disabled people are often restricted to mail order shopping, special clothing demonstrations, or assistance from a carer or relative, due to various reasons.

Furthermore, clothing should be easily available for *reasonable price*, an important factor, that ought to be considered when manufacturing textile or clothing products for the disabled. It is, however, not always remembered that there are other factors that influence the total costs of the product, for example, service costs and durability. The argument that good *ergonomics* is good *economics* (Hendrick, 1995) may be too narrow.

Human factors and *ergonomics* must go beyond economic concerns. Broad aesthetic and ethic considerations of a design situation may suggest that good *ergonomics* sometimes is not necessarily good *economics*.

Timing is also critical in women's fashion, which emphasizes change and new lines, and this makes turnaround from design to manufacture and distribution very fast.

The story of fashion is largely told as the story of women's clothing and its rapid changing aesthetic. However, according to Fine and Leopold (1993:128), explanations, which see this as emanating from some essential feminine psychological impulse, are highly implausible. Instead they argue that the evolution of the fashion system represented an attempt to accommodate the failure to achieve mass-production fully. Fashion as transient, fast changing style has become the motor of women's clothing and this explains why clothing production leads to some of the worst labour conditions for workers. Fast turnover of style puts pressure on manufacturers to work quickly and at low cost to reduce the risk of over-production for clothing which, once ready, is no longer 'in' fashion. Producers are therefore more likely to rely on subcontracting which can seek out the most 'flexible' workforce, i.e. the one that can be picked up and laid off at will, with no demand for sickness benefits, maternity leave and the like (Entwistle, 2000:218-219).

Moreover, lately, the textile industry and consumers' responsibilities in moving toward the production of *environmentally sound textile products* are discussed. The assessment of the *environmental impact* of a product is a complex issue, and solutions cannot be achieved without action by the government, industry, and the consumers. According to Chen and Burns (2006:248-261), the increasing public awareness and sense of social responsibility related to *environmental issues* have led the textile industry to manufacture products with improved environmental profiles. New processes used to produce cotton,

wool, nylon, polyester, rayon, lyocell (Tencel®) and leather, and their potential environmental impacts using selected criteria, are being evaluated, while an analysis of the measures the textile industry has taken to reduce the adverse environmental impacts is provided.

Furthermore, clothing and other textiles, which are worn in close contact to the body, should not cause any kind of discomfort. Severe and prolonged discomfort caused by clothing, might lead to unbearable suffering or health risks. Different aspects of *comfort*, which need to be considered, are thermal, tactile factors, freedom of movement, pressure, non-allergenic, etc. In certain cases, the textile products should also be expected to protect the wearer from risks in the environment.

Overall, a paramount factor, when designing clothing for individuals with divergent body figures, is *Size*. The quest for garments of the right size that fits well, feels comfortable and allows the body to move naturally has always remained elusive, especially in mass-produced garments, where patternmaking models may not reflect measurements of current populations' figure sizes and shapes (Otieno, 2008:76). As clothing industry evolves from *mass production* to *mass customisation*, there is an urgent need to verify existing patternmaking systems and methods, in order to test their effectiveness. With the new scanning technologies, it is anticipated that such procedures will be utilised with variation in the analysis of mathematical formulae for size chart development, based on researching clothing anthropometrics. This '*local*' process can help make products not only more aesthetic and ergonomic, but also more economical (reduction of production cost).

In this particular research study, the above dual-process methodology proposed was applied in a new sizing system and a pattern design method based on body asymmetry,

due to scoliosis (multi-dimensional construct analysis), in combination to a survey investigating the girls' with scoliosis tastes and needs and the wearer trials of the constructed garments (psycho-physical analysis). Therefore, new sizing systems, based on anthropometric research and data derived from human bodies with non-standard figure types (i.e. bodies with scoliosis of the spine) would enhance existing patternmaking systems and methods, in order to produce apparel with improved fit.

Chapter 6

Current Sizing Systems and the need for improved Garment Sizing and Fit – A Case Study Comparison of Body Measuring Methods using manual and scanning technology

Garment sizing becomes related to body sizing, due to the fact that garment dimensions are often calculated by adding the corresponding ease amounts to the body dimensions. The concept of body sizing lies behind the idea of segmenting the population into size groups of similar body dimensions, so that a single garment created for a certain size group can fit all the people belonging to that size group. Therefore, a 'clothing sizing system' is a set of clothing sizes that is created by an apparel firm to fit the range of people in a target market, usually derived from anthropometric data of the targeted population (Petrova & Ashdown, 2012:268).

Ready-To-Wear clothing has existed since the industrial revolution. Previously, clothes were made to fit each individual either by the wearer themselves, family members or professional dressmakers or tailors. The first grading systems were the proportional dressmakers' systems used between 1820 and 1838. They used a single body measurement, such as bust measure, from which the other pattern dimensions were then graded in equal proportions (Kidwell, 1979:20). These were based on tailors' experience and not on scientific anthropometric studies (Laitala, Klepp & Hauge, 2011:20). The first scientific size charts were published by the British Standards Institution (BSI) in 1953, including a set schedule of code sizing related directly to body measurements. In the US, the first standard clothing sizes - CS 215-58 - were published in 1958 (US Department of Commerce) (Laitala, Klepp & Hauge, 2011:21).

6.1. Sizing Systems

A comparison of the sizing systems developed in several countries - the USA, the UK, Austria, Germany, Hungary, Japan and South Korea – has shown that the way of labelling garment sizes has varied from one sizing system to another. Most of the sizing systems classified figure types by height and drop value (the difference between hip girth and bust girth measurements), with a slightly different way of classifying garments and key dimensions of garment types, in each system. Recognizing the need for greater uniformity, the International Organization for Standardization (ISO) developed an international size labelling system. Many countries, including the UK, Japan, South Korea and Hungary, revised their size labelling systems by adopting the ISO system (Jongsuk & Jasper, 1993:28-37). The development of an international sizing system for clothing started in 1969 and the first international standard for clothing size designations, including definitions and body measurement procedures, was finally published in 1977 (ISO 3635), and later modified in 1981. The European committee for standardization has adopted a modified version of this standard in to their work (EN 13402-1 2001), while they have experienced problems in reaching a common size code, since it has to be informative and indicate sizes accurately, but at the same time not too complicated for the consumers from different nations to understand or for the apparel industry to use (Laitala, Klepp & Hauge, 2011:21).

6.1.1. Grading and Sizing Variations within the Industry – Current Sizing Systems

The most common type of sizing system in the apparel industry starts with a *base size*, which is then proportionally graded (scaled) to create a multiple set of sizes. The standard practice of mass-production is to create a range of sizes by increasing and

decreasing measurements from a sample size garment (*base size*) that fits the sample size fit model (Price & Zamkoff, 1996). Sizing systems can use *generic labels*, such as **small, medium, large**; *numbered sizes* such as **10, 12, 14**; or *body measurements* such as **17" neck** and **32" sleeve length**. Sizing systems vary in range from only a few sizes to a full spectrum of sizes, for example **2 to 20**.

Usually, an apparel company defines a target market and typical customers by identifying demographic characteristics, such as age, income, ethnicity and lifestyle. Then the firm chooses a single person -- the *fit model* -- to be the idealized body shape for that product and market. *Prototype garments* are created, then evaluated and modified in fitting sessions on the single fit model. A *base size pattern*, often size **8** (UK) for women, is perfected for this prototype garment, and proportional grade rules are used to scale a set of patterns up and down for the rest of the size range, e.g., **4 to 16** (UK).

The most common grading method used in industry, today, is the *proportional grading*, whereby both *standard* and *variable* grade rules are used (Bye *et al.*, 2008:80). *Standard grades* are the same for all sizes, whereas *variable grades* change according to the difference in circumference between sizes (Price & Zamkoff, 1996). The *vertical* and *horizontal* intervals of the body size table are applied to the construction points of the pattern to be graded, while the ease amounts included in the *base-size* pattern will remain the same to all garment sizes. *Proportional grading* produces patterns that change proportionally in circumference and length; however, people larger in circumference are not necessarily taller, which creates multiple fitting problems (Cooklin, 1990). This practice of sizing systems has been challenged by the idea that garment ease may need to vary according to size, rather than being constant for all sizes dimensions (Petrova & Ashdown, 2012:269). After assessing size charts from 17 sources, Schofield and Labat (2005:135-150) found that there were constant intervals

between sizes within a grade, while the vertical measurements increased as the size increased, and that there was a constant difference between principle girths for all sizes. Ashdown (1998:324-341) investigated the structure of sizing systems utilising the 'goodness of fit' analysis and concluded that size assignment and ability to cater for outliers resulted in improved fit in existing systems, while Yoon and Jasper (1996:89-95) developed a size labelling system for ready-to-wear women's garments, suggesting that key dimensions should present strong correlations with other dimensions. Gupta and Gangadhar (2004:458-469), using the principal component analysis to generate short, medium and tall body categories, developed 11 size charts for India with bust and hip girths as key dimension, while Vronti (2005) focused on developing size charts and a conceptual framework on the role of sizing in the marketing of women's wear, concluding that a '*Mediterranean*' size chart should be developed to meet the needs of many countries in this region. Overall, Loker *et al.* (2005:1-15) conducted a fit analysis on 156 participants in the US aged 34-55 years, of a ready-wear pant graded from a size **8** (US) fit model, finding that fit was rated higher for sizes **6** to **10** (US) and lower for sizes **12** to **16** (US), assuming that the smaller sizes received higher ratings because they were closer in proportion to the fit model, than the larger sizes. To overcome this problem, another industry grading method – *group grading* – could be practiced, whereby two patterns are developed for the sizes at extreme ends of the size range, requiring *two* fit models, although this is rarely practiced, due to higher production costs.

Today's apparel industry is based on a system where clothes are made in ready-to-wear (RTW) sizes and meant to fit most people. However, standardization could result in more limited sizing options that fit a smaller portion of the population, due to the fact that current size charts do not accurately reflect body measurements across sizes or changes in body shape, as human bodies do not grow proportionally, having resulting in

current grading practices, contributing to fit problems. Bye *et al.* (2008:79-92) compared *traditionally graded* to *fit-to-shape* patterns and found that the greatest variations between the two types of patterns occurred between sizes **14** and **16** (US Misses sizes based on ASTM D 5585), pinpointing that for size **16** (US) and up, neck and armcye circumferences were too large, whereas bust dart intakes were too small. This establishes the findings of an earlier study, whereby large-size women had identified size and fit as the most common problem when questioned on garment satisfaction (Chowdary & Beale, 1988:783-788). Other studies have also pointed out that consumers are discontent with the use of current sizing systems: size designations are not accurate enough to find clothing that fits, and different sizes are poorly available, while there are disparities within clothing sizes used today (Laitala, Klepp & Hauge, 2011:19), the most obvious being the national labelling differences between countries. Chun-Yoon & Jasper (1993:28) and Ujevic *et al.* (2005:75) found that there were significant differences even though clothing would have the same size designation, while the average body dimensions have considerably changed in the last decades. Ujevic *et al.* (2005:71) investigated these differences in a number of European countries and compared the garment size systems, whereby it was found that most countries still possess their own official garment size systems, which differ in many aspects from the others. In addition, larger firms in some countries use their internal standards, which vary to some extent. The conclusion based on research is that these standards depend on the function and purpose of the garment, on trends in fashion, on the design and on the economy of production (Ujevic *et al.*, 2005:71-78).

To overcome this problem, international clothing chains often give several size designations in the same label, which are supposed to be equivalent sizes for different countries. The sizing differences are not only a problem within the international markets,

but also on a national level, as great disparities can be found within sizes, in the same country (Laitala, Klepp & Hauge, 2011:21). Moreover, several studies have shown that the female *beauty ideal* has moved toward an increasingly thin standard (Garner 1980: 489; Silverstein et al. 1986:895; Groesz et al. 2002:2; Cortese 2008:36). The results from a survey by Laitala, Klepp & Hauge (2011) indicate that it is easier to find clothing that fits for consumers whose bodies more closely resemble the beauty ideals (Laitala, Klepp & Hauge, 2011:35), whereas an earlier study by LaBat and DeLong (1990:47) had suggested that it was inevitable for women to compare their bodies to an ideal when they tried to fit their body to available clothes, and it was, therefore, inadequate to base sizing systems on ideal proportions. For some consumers the size code in itself is important, beyond finding clothes that fit the body. The clothes' measurements refer to the measurements of the body, which again are measures of beauty and self-control, particularly for women. Women can, for instance, quantify the size of their bodies by determining if a garment fits their body or not (Colls 2004:588).

Hence, the industry faces challenges as RTW clothes are supposed to fit a variety of bodies, while at the same time, economic and practical limitations in production and profitability have to be kept balanced. It is costly to produce clothes in several different sizes and therefore, the industry concentrates the selection of sizes to fit the target customer groups. This means that the apparel industry has to prioritize some customer groups over others (Laitala, Klepp & Hauge, 2011:20) and, presumably, that certain consumer groups have the most trouble finding clothes that fit their bodies and preferences (Ashdown & Dunne, 2006:121). The use of multiple fit models in a range of more than five sizes may be the solution to this problem: in ranges up to five sizes, the fit model should be in the middle of a sizing group that does not range more than two sizes up or down (Bye *et al.*, 2008:79-92). Another potential solution could be automated

custom fit, based on technological advances, such as 3D body scanning for body measuring and automated CAD pattern generation, along with new manufacturing developments (Ashdown & Dunne, 2006:122).

Achieving the perfect fit of a garment, however, depends on more than just drafting the correct pattern size. The standard body measurements compiled by the pattern industry are simply average body measurements of women within a particular size range. Tables with standard measurements are used for each size, based on those average measurements (Laitala, Klepp & Hauge, 2011:20-41). Since individuals within that size may vary in any number of ways from the standard measurements, they serve simply as starting points from which a specific individual must make adjustments and alterations to fit their own dimensions. Although there is industry cooperation to some degree, clothing designers and manufacturers have their own reasons for changing the standards to meet the needs of their perceived market. These reasons include different ideas on how clothes should be cut, how much ease should be allowed, and how costs could be reduced. Some of these reasons are based on the way people, in general, are shaped. The *fit* of the garment is dependent on more details than the basic size. As Ashdown (1998:324) points out, size charts are often based on two or three body dimensions such as bust, waist and hips. The proportions and distances between these body measures vary greatly between the individuals. It has been shown that only 47% of the US female population fit the medium hip category, which is defined as hips being 2 inches greater than the bust (Cooklin, 1990). According to UK's national sizing survey performed in 2004, 60% of shoppers experience difficulty in finding clothes that fit (Bodometrics 2005:3; Treleaven 2007:113), while it has been shown that the customer groups that have most problems are mainly women, especially those who need larger sizes, and the elderly (Chowdhary and Beale, 1988:783; Salusso et al., 2006:96).

Attention has also been drawn to disabled users who have problems to find suitable clothing, not only due to sizes and fit problems but also regarding shopping possibilities and service at the stores (Thorén, 1996:389).

The poor clothing selection could, thus, be interpreted as giving lower priority to female consumers who differ from the ideals. The groups concerned are those who have the greatest difficulties in appearing well-dressed, even when they find clothes that fit their size (Laitala, Klepp & Hauge, 2011:35). Dressing a body that deviates from current beauty ideals is more difficult than dressing the ideal body (Entwistle 2000), while appearing well-dressed, modern, cool, etc., is problematic even if the clothes in themselves are '*right*' and fit their body size. In today's women's fashion the relationship between the body and the clothes is crucial. It is on the slim female body that clothes appear '*right*'. At the same time, a body in accordance with current body ideals will easily be perceived as beautiful and modern, regardless of whether the clothes are (Rysst 2008:119). Ideally, then, it should be the other way around: women whose body configurations deviate from the ideals have the greatest need for a wide selection of clothes. Wearing the right clothes with a good fit contributes to the confidence and comfort of the wearer both physically and socially. Being inappropriately dressed for an occasion can cause feelings of awkwardness and vulnerability (Entwistle, 2000:7). Therefore, everybody should have a possibility to dress appropriately (Laitala, Klepp & Hauge, 2011:22-23).

From time to time, however, different measurement and size charts have been developed for specific groups, such as people with Down's syndrome⁵¹ (Tam & Harwood, 1993), or individuals with short stature⁵² (Kohvakka, 1996), in attempts to mass-produce clothing, according to '*special size charts*', and help those specific individuals who 'came'

⁵¹ <http://www.growthcharts.com/charts/DS/charts.htm> (Accessed 20th May 2013)

⁵² <http://www.aafp.org/afp/2008/0901/p597.html> (Accessed 20th May 2013)

within sizes. Nevertheless, the problem in producing garments for such small target groups would be the small potential market. There might be a large number of people who would benefit from this, in the whole world, but it would be rather impossible to reach them all, due to time and cost issues. Furthermore, the way of dressing and the styles preferred, within such a small target group, would probably vary as much as they would vary among individuals with *standard* body types. As Hernandez (2000:93) points out, studies have shown that impaired or disabled people want to select their clothes from the regular supply in conventional retail stores. Comparing to the global clothing market, such target groups are rather small. If they could be included in the regular global clothing market, it would benefit clothing manufacturers because profit would increase, due to increase in the variety of demand and supply.

To conclude, by definition, ready-to-wear clothing (RTW) is developed and offered in a variety of styles and stocked in a limited number of sizes for sale, before potential customers select and try on styles of interest. Most sizing systems are derived from ASTM standards (ASTM D5585-95, 1995; ASTM D6192-98, 1998; ASTM D6240-98, 1998; ASTM D4910-99, 1999; ASTM D 6458-99, 1999)⁵³. However, individual firms have always interpreted the standards differently in order to distinguish their garments from their competitors' garments. In other words, size (and the resulting fit) is used as a marketing strategy. A size **10** (UK) at one firm is not the same as a size **10** (UK) at another firm (Loker, Ashdown & Schoenfelder, 2005:1-15), leading many consumers today to express frustration over the sizing systems and actively seek out different apparel brands, in order to identify brands that sell clothes that fit their body size and type (LaBat 2007:103). Such frustration is typical of how sizing systems are experienced today, as finding clothes that fit the body becomes more and more complicated.

⁵³ <http://www.astm.org/Standards/> (Accessed 18th May 2011)

6.1.2. Size Labelling and Vanity Sizing

The most common explanation for intentional sizing variations is the so-called *Vanity Labelling* or *Vanity Sizing*, a growing trend which is seen as a way of gaining a competitive edge, labelling the garments smaller than they actually are, in order to flatter the customers as they fit into a smaller size than their 'real' size (Kinley 2003:21; Ennis 2006:30). Other explanations give more coincidental disparities, such as the use of different size fit models, size statistics from different resources, and the grading from the fit model to the other sizes (Ashdown 1998:324; Kinley 2003:20), since the anthropometric data that may be used as a base for size charts can come from many different sources. Thus, there are also variations between the decades, nations, as well as company specific adjustments to fit for a specific customer target group (Laitala, Klepp & Hauge, 2011:22).

Size labelling is a communication system between manufacturers and consumers. The purpose of the system is to make it simpler for the consumers to find clothes that fit. This presupposes three things: the manufacturers must label the sizes correctly, the consumers must understand and trust the size labelling, and the clothes must fit the consumers' bodies. Results from a *Laitala, Klepp & Hauge* survey revealed flaws in all these three areas. Producers label the clothes incorrectly; one pair of trousers labelled **Large** can be smaller than another one labelled **Small**, while they produce too few selections, especially in the big sizes, and large women (and very large men) have the most trouble finding their sizes at stores (Laitala, Klepp & Hauge, 2011:36-37).

Consumers, on the other hand, who have a body out of touch with the existing beauty ideals express discontentment with the sizing systems and the poor selection available and do not trust the labelling system (Laitala, Klepp & Hauge, 2011:37). *Vanity sizing* is

the most likely explanation of the fact that many women report poor-fitting garments, when they are actually wearing the wrong size for them (Honey & Olds, 2007:320-331). Consumers tend to blame themselves when the clothes do not fit their bodies, while the survey pointed out that the industry is to blame, as they do not produce clothing for all customers (Laitala, Klepp & Hauge, 2011:37).

Unfortunately, although it would be easier for the RTW customers, it does not seem feasible for the apparel industry to shift to a standard sizing system that all firms agree to adopt (e.g. all size **10s** UK fit the same way), as this would have the effect of decreasing consumers' fit choices. An alternative approach would be to improve each firm's unique sizing system to fit more people within the group that they consider to be their target market. The focus on a specific target market also allows the company to focus on the particular styles desired by that target market. An existing sizing system could be improved mainly by changing the *base size specifications* to correspond more closely to the proportions of the majority of the people in the target market, or by developing a new sizing system that may have six or eight sizes that are based on *target market body and shape measurements* rather than on *proportional fit assumptions*. Both these approaches are logistically and financially feasible using the 3D body scanner and computer-aided design (CAD) grading systems (Loker, Ashdown & Schoenfelder, 2005:1-15).

To conclude, in clothing engineering, anthropometric measures are applied in the domain of garment construction. The execution of clothing requires typical body measures, as well as their mutual proportions. The results of anthropometric measurements of a sufficiently vast population can be used for determining the national garment size systems. Thus, ISO, the international standards organization for setting

industry standards, passed in 1989 the norm ISO 8559 for anthropometric examinations, provided with a list and description of body measures in view of constructing garments (Ujevic *et al.*, 2005:71-78).

6.2. The Importance of Garment Sizing and Fit

Fashion and beauty have always helped shape history and today, more than ever, we find ourselves under increasing pressure to think about what we wear, what we look good in, and how to enhance our body shape and size best. Behind this, seemingly, superficial industry, however, lies a technical thinking firmly grounded in science and technology that provides a critical appreciation of the technological developments and scientific understanding of the appearance and fit of clothing, creating, therefore, an urgent need to bridge beauty and fashion design. Hence, garment evaluation technology, garment drape and human anthropometrics could form the base for the development of new sizing systems based on individuals' with non-standard body figures dimensions.

6.2.1. Body Sizing based on Anthropometric Surveys

One of the greatest challenges facing apparel companies today is to provide quality fit to a broadly defined target market. Two issues have limited the resolution of this problem; firstly, the lack of data on fit characteristics of garments for different body sizes and shapes and, secondly, the lack of current anthropometric data to describe the civilian population (Ashdown & Loker, co-leaders (Cornell); Rucker, 2007)⁵⁴.

Measuring the human body has been important in developing garments to fit the body, and systems have reflected technology, consumer needs and focus of the apparel industry. Generally, the most notable differences in body size and shape relate to ethnic

⁵⁴ <http://www.ntcresearch.org/pdf-rpts/Bref0607/S04-CR01-07.pdf> (Accessed 13th March 2012)

diversity, age and gender. In principle, females are smaller than their male counterparts except in hip dimensions. With age increase, many adults become shorter and many, also, heavier (Kroemer & Grandjean, 1997).

After studying and comparing sets of grade rules from 17 different text books, Schofield and LaBat (2005:135-150) suggested that grading practice is not based on anthropometric data and defined seven proportional rules, set increments and other assumptions that form the basis of grading, suggesting that traditional grading practices should be replaced with methods that actually reflect women's body measurements (Schofield and LaBat (2005:149).

Body sizing information is not only important to consumers, but to retailers and manufacturers, as well, while it could serve as a competitive edge. The processes of gathering accurate body measurement data, their critical analysis and logical interpretation into size charts are the cornerstone of sizing systems and, as such, are considered proprietary and marketing tools for retailers and manufacturers, while used for size communication by consumers, for creating consumer satisfaction and for creating niches in the markets. Conducting anthropometric surveys by proper planning and organisation will, therefore, benefit clothing companies to develop size charts, size ranges and grading increments, based on their target markets without resorting to trial-and-error approaches and, thus, contribute to the growth of this subject.

Interaction of multiple factors including the *size*, *proportions* and *posture* of the wearer as well as the dimensions and drape of the garment, are involved in defining the fit of a garment. The concept of *good fit* varies, as it is affected by the fashions in fit of the time, the style and function of the garments and wearers' individual preferences, while the issues defining good fit can be complex and ambiguous. The acceptance or rejection, however, of clothing is highly dependent on fit and it is crucial that these issues should be addressed.

The search for perfect clothing fit has a long history relating to various efforts to determine body anthropometry for the development of patterns and garments in the clothing industry (Apeagyei, et al., 2007:332-348; Fan & Hunter, 2004), while the shapes of human figure types continue to change, mainly, due to sedentary lifestyles, dietary habits, migration patterns and the impact of rising trends that affect body shape ideals (Apeagyei, 2008:3-11; Workman & Lentz, 2000:251-256; Tamburrino, 1992a: 44-47, 1992b: 52-60 and 1992c: 68-74).

6.2.2. Figure-Type Variations and Fit Assessment

Fit can be evaluated in all stages of garment assembly, from product development to distribution to the retailer. Although it is difficult to establish a precise definition of fit, while each company interprets these size standards in a slightly different way to make their patterns fit the greatest number of their customers, some fitting standards are common throughout the apparel industry and standard sizes allow consumers to purchase the same pattern size regardless of brand. This eliminates a lot of confusion, especially when compared with the sizing of ready-to-wear clothing (The Editors of Creative Publishing International, 2005:11).

The first step toward achieving a good fit for an individual with a distinctive body configuration (i.e. due to scoliosis) is to become familiar with their figure and the ways it varies from the average or ideal. Some of the great advantages clothes can offer – besides providing warmth, protection and a creative outward appearance - are to camouflage a figure variation, draw attention away from a figure variation, or create attractive illusions about a figure. These are the goals of fashion designers, image consultants and smart dressers worldwide.

Today, one major source of apparel fit problems can be attributed to the current pattern grading and sizing systems, which assume that proportionally graded sizes can fit most

of the population. Current methods of creating sizes and analyzing garment fit are, either based on measurements of one ideal customer embodied in a *single fit model*, either adjusted for additional sizes by using grade rules to define proportional increases and decreases from the base pattern, or evaluated on the fit model, visually and in two dimensions, by comparing linear garment measurements to linear body measurements (Keiser & Garner, 2003:301-324).

Nonetheless, a study by Ashdown (1998), based on anthropometric data, has shown that little correlation exists among body measures, which means that there is much proportional variation in the population that is not well addressed (Ashdown, 1998:324-341). Moreover, females who have the same bust, waist or hip circumference may have different figure shapes (Kwong, 2004:198-233). Hence, it is not surprising that in a study by *Kurt Salmon Associates*' (2000), 50% of women claimed they could not find apparel that fitted them, while other studies have indicated that fit problems are the reason for 50% of catalogue returns (DesMarteau, 2000:42-56; Goldsberry, Shim, & Reich, 1996:121-132). In a more recent study of young women's attitudes toward clothing fit, by Alexander *et al.* (2005), 54% of the respondents reported being '*somewhat satisfied*' to '*mostly satisfied*' with the fit of RTW apparel (Alexander, Connell & Presley, 2005:52-64).

Generally, the fit of a garment is described by five components – ease, grain, line, balance and set – which are evaluated interactively to determine whether a garment provides good fit or not (Erwin, Kinchen & Peters, 1979). A traditional method of evaluating fit is by analysing the direction, magnitude and amount of wrinkles or stress folds that occur in a garment that doesn't wrap properly around the body (Watkins, 1995). These can be of three types – vertical, diagonal and horizontal – each indicating different problems, such as insufficient, excess or misplaced ease. Current objective methods of analyzing garment fit involve comparing the garment measurements to the

body measurements using linear measurements and utilizing pressure gauges to measure the amount of pressure a garment places on a specific body location. Although these methods are useful for evaluating simple garment fit issues, they are not adequate to investigate the complexities of the multifaceted relationship between the body and clothing for a large number of customers with a variety of body types within each size. Major fit problems and resulting women's dissatisfaction, related to misfit, are thought to be caused by sizing systems and pattern grading (Ashdown & Dunne, 2006:121-136). Fit assessment involves both the physical and psychological attributes associated with comfort and satisfaction, while good fit requires the proportional balance between body and garment, which can only be achieved with advanced development and application of accurate sizing systems, effective patternmaking and quality manufacturing. Therefore, fit should be improved by adjusting existing sizing systems for specific target market populations of individual apparel firms, such as for *petite* women, or for *plus-size* women, or, as proposed in this research, for *adolescent girls with scoliosis*.

Anthropometric research, nevertheless, can be time consuming and costly. As well as being considered proprietary, precise, detailed information on applications, techniques and resulting data is not easily accessible in the public domain. 3D body-scanning technology, on the other hand, could be used to efficiently extract body measurements and to quickly analyze a large number of body shapes (Chen, 2011:302). Recent studies involving the application of 3D body scanners have confirmed the existence of various female body shapes (Apeagyei, 2008: 3-11; Faust *et al.*, 2006:71-83; Simmons *et al.*, 2004a:1-15), even within specific size categories. The 3D body scanner is a promising new research technology that could contribute to revolutionary changes in the conception, design, manufacture and distribution of apparel. Since this particular research study, however, has taken place in a Greek context,

whereby body scanning technologies are not yet developed, the 3D body scanner was not used in the study, following an investigation comparing manual and scanning procedures of body measuring (see Chapter 6.5).

6.2.3. New Methods applied in Industry for Sizing Garments and predicting Garment Fit today

In the last decades several comprehensive national anthropometric sizing surveys that utilize the new body scanning technologies have been conducted (Meunier, 2000:715-718; Ashdown & Dunne, 2006:123; Bye et al., 2006:74). According to Meunier (2000:715-718), the use of three-dimensional landmark coordinates for body type is superior to the use of circumferential measurements in predicting clothing sizes. The studies indicate that the population has changed considerably during the last decades; for example, the average waist girth of British women has increased by 15 cm since 1952 (Bodometrics 2005:3), and 38% of women are either overweight or obese. This means that most old size charts are out-dated, and the international clothing industry has a need for more international, standardized solutions (Stylios, 2004:135).

Understanding the relationships among garment fit variables is essential to advancing the process of garment development especially with respect to programming computer-aided patternmaking systems accurately. Fit experts utilise their practical knowledge, but it is generally unrecorded, while patternmaking texts provide information on body-to-pattern variable relationships that is not well documented. Building patternmaking theory can ground the practice and lead to a better understanding of body-to-pattern relationships (McKinney, Bye & LaBat, 2012).

To date, the pattern industry uses a common set of basic figure measurements based on statistical averages for bust, waist, hips, back waist length, and height. Each company develops a set of sizes for its target market, and has to maintain sizing consistency for all styles throughout the seasons. Firstly, a fit model or a chart with measurements, appropriate for the target market, is selected, based on which garments are designed and fitted in the base size to this fit model or chart, and then the pattern is proportionally graded to create a range of sizes (Ashdown & Connell, 2006:138).

Hence, proportional grade rules do not address the differences in the basic shapes and body proportions of the population - such as small or large waist, short or long torso, or differences across ages and target markets – as a single fit model has a particular body shape that is then translated to the full range of sizes. Fit tests are, generally, conducted with the full range of sizes and on participants chosen to represent the population variation so that both garment fit and sizing systems are tested. Providing good fit using a finite set of sizes for an almost infinite range of body types is a challenging task. Possibly, the new information available from the 3D body scan research may help industry meet this challenge⁵⁵.

Nonetheless, inexpensive solutions for validating size charts and predicting garment fit can be given by different statistical models, adopted by various researchers today, which do not require the need of making up garments or performing fit tests, in order to evaluate the fit of a specific garment for a number of individuals who fall in that garment's size range. A novel approach for constructing apparel sizing systems was introduced by McCulloch, Paal and Ashdown (1998:492-499), based on the goodness of fit that an individual experiences when wearing a garment of a particular size. Using this measure, known as the '*aggregate loss*', various existing US sizing systems were compared

(Ashdown, 1998:324-341), while Gupta and Gangadhar (2004) validated 11 Indian sizing systems by calculating the '*Aggregate loss of goodness of fit*', using a simple mathematical formula, calculating the average of the Euclidian distance in the three-dimensional space of the individuals from their allocated size (Gupta & Gangadhar, 2004:467). Overall, Honey and Olds (2007:320-331) used the *L-statistic*, another new method of comparing any individual to any sizing system and to assess the lack-of-fit between any sizing system and a sample of individuals' bodies. The use of 3D body scanners in close association with the *L-statistic* has potential for use in revising current sizing systems, for continuous revision of future sizing systems and for the development of new clothing technologies, on the grounds of developing a standardised body scanning protocol, for worldwide use (Honey & Olds, 2007:329).

To conclude, the dress toiles derived from the basic 'pattern blocks' designed to serve the purpose of this study (see Chapters 8 & 9) were evaluated and analysed based on the '*Aggregate Loss of Fit*' methodology (Chapter 10.1:361).

6.3. Using 3D Body Scanning Technology to improve garment fit

Although traditional methods of evaluating fit by analysing the direction, magnitude and amount of wrinkles or stress folds (Watkins, 1995) and other manual methods such as comparison of linear measurements, are useful for evaluating simple garment fit issues, they both provide only limited information about the human body shape and proportion. On the other hand the body scanner has the ability to obtain 3D data of the surface of the human body, providing valuable information to improve garment fit (DesMarteau, 2000:42-56; Simmons, Istook, & Devarajan, 2004a, 2004b).

The development of improved technologies in Computer Aided Design (CAD) can provide the solutions to apparel industries (Bye *et al*, 2006:66-79), while technologies

⁵⁵ <http://www.bodyscan.human.cornell.edu/scene7354.html> (Accessed 5th November 2011)

such as three dimensional (3D) body scanning and Computer Aided Manufacturing (CAM) can also reduce fit problems and make mass customisation viable (Chi and Kennon, 2006:166-178).

Therefore, the 3D body scanner was used in the research, as part of a case study comparing manual and scanning procedures of body measuring (see Chapter 6.5).

6.3.1. Advantages and Applications of 3D Body Scanners

The development of 3D body scanning technology allows for the quick and consistent extraction of body measurements and can potentially generate customized fit for any number of people. Most scanners collect over 300,000 data points, as x, y, z coordinates, and these data are being analyzed in a variety of applications, using *non-linear* measures such as *surface area*, *volume*, or data from *body slices* that may be better able to comprehensively analyze the human body and address problems of garment fit, relating to shapes, angles, and relational data points (Simmons & Istook, 2003: 306-332).

For the clothing industry, such scanners capture an accurate 3D representation of a garment's relationship to the body, minimizing visual distraction (Ashdown *et al.*, 2004:1-12), while the extracted measurements and the virtual picture are the foundation for individual pattern construction and digital data management. The 3D image allows instant evaluation regarding validity of the scan; and the dimensions and shape data could be used repeatedly for various garments without the need for repeated measurement. The measurements obtained using these technologies are more precise and reproducible than those obtained through the traditional, physical measurement process. Furthermore, measurement data can be renewed or revised at any time. The 3D scanning technologies, used for body measurement extraction on today's market, are based on various systems. Although there are variable and incomparable

measurements between them (Simmons & Istook, 2003: 306-332), their common aim is to scientifically extract anthropometric data in a valid and reliable manner (Apeagyei, 2010:58-67).

Recent anthropometric research using body scan data, has been conducted by consortiums in several countries with members across several industries or specifically in the apparel industry (Treleaven, 2004:29-31). The consortium members are provided with measurement information for thousands of people, in age and gender categories, for application by designers and manufacturers to improve the fit of garments. Body scanning technology has been applied in industry to improve garment fit by several well-known firms.

Brooks Brothers (www.brooksbrothers.com) creates custom fit suits and dress shirts for men based on body scan measurements. *Benchmark Clothiers*

(www.benchmarkclothiers.com) offers a business-to-business (B2B) service by deploying scanners to retailers so they can measure customers and offer made-to-measure apparel through partnership with *Benchmark Clothiers*. *Bodymetrics*⁵⁶, a London-based body-mapping technology company, uses software that can digitally analyse a person's body allowing them to find perfect fitting clothes and jeans trousers, before they try them on, thereby reducing returns, providing a body-mapping service at *Selfridges*, a luxury retailer, for premium jeans retailing⁵⁷.

Concurrently, researchers at universities and in the armed forces are using a variety of approaches with body scan technology to analyze the complex relationship between the body and the fit of a garment. Examples include projects on scan measurement extraction and use (Pargas, Staples & Davis, 1997:157-172), shape analysis and

⁵⁶ <http://www.bodymetrics.com> (Accessed 13th March 2012)

⁵⁷ http://www.bodymetrics.com/assets/Bodymetrics_Launch.pdf (Accessed 13th March 2012)

quantification (Jones *et al.*, 1995:7-17), fit analysis (Ashdown, Loker, Schoenfelder, & Lyman-Clarke, 2004:1-12; Paquette, 1996:11-15), use of scan data in a mass customization scenario (Fralix, 2001:1-7) and automated pattern making from body measurements (Kang & Kim, 2000:240-254). These are the pioneer studies of body scan data applications to improve garment fit.

A decade ago, Devarajan and Istook (2004:1-23) integrated a body-scanning system, developed by [TC]², with *Female Figure Identification Technique* (FFIT) software, based on computing selected circumference measurements, to analyze females' body shapes. On the contrary, Cho *et al.* (2006), instead of using circumferential dimensions to classify body shapes, have used body scanners to extract back and hip angles - crucial for creating pattern profiles and making judgements about the intake of bust and shoulder darts and the amount of shoulder inclination, in order to define and classify posture (Cho *et al.*, 2006:96-107). Moreover, Chen (2011) used a 3D body scanner to quantify upper physical characteristics based on angle measurements, in order to develop stimuli for investigating body shapes, predicting intake of bust, back and waist darts on block patterns and evaluating how standing posture affects apparel fit (Chen, 2011:301-310). In addition, 3D body scanner applications, with the aim of customization, are numerous. Sul & Kang (2006:31-42) developed algorithm of direct 2D pattern development from 3D data, Daanen & Hong (2008:15-25) developed made-to-measure patterns based on 3D whole body scans, while Chen (2007:131-144) evaluated the fit of basic garments within the made-to-measure process for various figure characteristics. Concurrently, Loker *et al.* (2005:1-15) tried to describe how size-specific analyses of body scan data can be used to adjust RTW sizing to improve garment fit, while a study by Shin & Istook (2006:1-15) was related to pattern data format standardization between apparel CAD and 3D body scan with *Extensible Markup Language*. Istook (2002:61-76) outlined the operations involved in CAD systems, in order to automatically customize garments for fit,

while Griffey & Ashdown (2006:112-120) developed an automated process for the creation of basic skirt blocks from body scan data. Song & Ashdown (2012:315-329) worked on the development of automated custom-made pants, driven by body-shape, proving that incorporating body shape information into block patterns can generate custom patterns with better fit, while Ashdown *et al.* (2008:199-213) also developed and tested a method of automatically locating the side seam for torso-fitting garments from body scans for a variety of body types. Simmons *et al.* (2004:1-15) worked on a female shape classification system, that involved using body scan data to ensure satisfactory fit, while, in a similar study, Connell *et al.* (2006:80-95) developed body shape assessment scales (BSAS) using experts' knowledge.

Overall, Kim *et al.* (2010:142-146) developed a semi-automatic process of making final 2D pattern from 3D scanned surface, using triangle simplification (dividing each pattern block into triangular surfaces), that fit tightly to an asymmetrical female manikin without considerable stress or ease on the body or textiles. This last attempt enabled pattern making, which mostly relies on 2D measurement values (circumference or distance) that match only to the outline dimension of the conventional 2D pattern making frame, to reflect the missing information on the inner variation of the curved surface of the body, accurately.

In general, the objective of all the above studies was, either to develop custom clothing from an individual's scan data and CAD patternmaking software and hardware, either to develop an improved sizing system that could be adopted by industry, or to attempt virtual draping on the body in order to create apparel patterns, either from a 2D pattern to a 3D virtual garment or *vice versa* (Loker, Ashdown & Schoenfelder, 2005:1-15).

According to Loker, Ashdown and Schoenfelder (2005), collecting body scan data from target market samples and using it to modify existing sizing systems, used by individual

firms, will improve sizing for many consumers within the current shopping model and will help identify potential design adjustments that could be made, in order to increase the percent of acceptable fit within each size category for a target market (Loker, Ashdown & Schoenfelder, 2005:1-15).

6.3.2. Limitations of 3D Body Scanners

Realistically, any large-scale use of body scan data to improve apparel fit will not be in custom clothing or industry-wide sizing system changes. The majority of apparel customers, especially women, have grown accustomed to having a broad selection of garments from which to choose based on style, colour, and fit. They are accustomed to trying on a number of garments and selecting from them. Custom clothing requires imagination, prepaid commitment, and, currently, a limited number of garment type and style offerings.

Retailers such as *Levi Strauss* and *Brooks Brothers* have taken initial steps to help consumers find better fitting garments by NTC Project: S01-CR01 (formerly S01-B01)⁵⁸, using customer measurement information to either create custom fit garments or give consumers the ability to visualize their potential purchases in virtual try-on software programs (Wellington, 2001:B10). While these methods are innovative, they are merely a first step in solving garment fit problems for consumers. Research analyzing the complex relationship between the consumer's body and the way a garment fits on his/her body is needed to make significant strides in improving garment fit for apparel consumers. Consumers, today, have become savvier than ever, and as the demand for well-fitted garments is increasing, 3D body scanning technology is being viewed as a significant bridge between craftsmanship and computer-aided design technologies. Currently being explored by academic research and not as yet widely implemented across retail sectors,

⁵⁸ <http://www.explore.cornell.edu/bodyscanner> (Accessed 16th November 2011)

it is expected to facilitate consumer satisfaction and reduce commercial waste due to 'ill-fit' returns. There is therefore a vital need to authenticate procedures and establish systems for practice (Apeagyei, 2010:58-67).

6.4. Virtual Try-on Systems using Body Measurement Input to improve garment fit

A 3D virtual clothing system for mass-customisation means a system with which customers can try virtual garments customised according to their size and taste on a virtual avatar reflecting their body shape.⁵⁹

With 3D visualizations provided by cutting-edge computer software, target market members in an apparel firm's actual clothing articles can be scanned and fit can be virtually evaluated. Separating the visualizations by size and viewing them as sets—e.g., all size **10**'s or all size **14**'s together - would help to begin to understand how many of the target market population can achieve good fit. Scans in each size can be sorted into like piles based on the fit problems identified visually or statistically, while problems that may occur for many participants in one size and across sizes can be addressed with appropriate solutions to improve fit (Loker, Ashdown & Schoenfelder, 2005:1-15). This technology is currently viewed as the frontier in solving fit problems, for instance by generating accurate data for the development of size charts, enabling a pragmatic approach to the offer of mass customization and also facilitating virtual model fit trials that enhance online clothing shopping experiences.

Digital technology introduced into the clothing and fashion industry is evolving to digital virtual fashions and consumer-centred mass-customised production systems. Today the application of such 3D virtual try-on systems is being expanded gradually in the clothing

⁵⁹ http://www.papersearch.net/view/detail.asp?detail_key=0b501632 (Accessed 15th March 2012)

industry. With the recent rapid development of digital technologies, such technologies are merged into various industries. As one of such trends, past *manufacturer-centred* mass-production systems are being changed to *consumer-centred* mass-customisation and made-to-measure (MTM) production systems. Along with this trend is coming the age of 3D virtual clothing that attempts to develop 3D digital fashion technologies and commercialize mass-customised apparel products through the fusion of digital technologies and the textiles and clothing industry.

6.4.1. Advantages and Applications of virtual Try-on Systems

Virtual garment try-on technology aims to provide optimal fit and revolutionize the online shopping experience. The main feature of this technology is the capability of virtually testing fit on individuals or retail-specified size models, either through manual input measurements or data acquired from 3D body scanners.

A digital pattern design is generated by two methods: the flat-pattern process, which is two-dimensional and the three-dimensional draping method, in which the flat fabric is directly draped on a 3D virtual body image. The 3D method provides well-fitting patterns, whereby the 2D patterns are generated using Artificial Intelligence (AI) Technology, which reduces the labour requirements (Yang, Zhang, & Shan, 2007:167-177). Research has been carried out to customize individual patterns by gradual mapping from 3D models to 2D patterns without considering the physical or mechanical properties of the fabric such as drape (Yunchu and Weiyuan, 2007:334-348).

In garment sampling and pattern environments, this technology would cut down on the amount of fit trial sessions undertaken by live models, leading to reduced costs towards fit trials, increased accuracy of targeted fit and results in reduced sample making. With virtual dressing rooms, consumers would also be able to virtually try-on selected garments and preview fit and appearance, enabled by personalised, animated avatars

that would enhance the shopping experience by offering fit assessment of garments, and would help consumers to identify the right size for clothing, with the aim of improving satisfaction and reducing returns due to poor fit. Apparel companies like *Sears*, *H&M*, *Adidas* and *Levi Strauss* are currently using virtual try-on systems, where the users generate their virtual avatar in virtual garments.

'*My Virtual Model*' (MVM)⁶⁰, a Montreal-based company has shown that people personalizing and designing their own clothes are able to view their designs on a virtual model that represents them, have a higher conversion rate and order more than average visitor (Guay, 2003). The '*Virtual Fitting Room*' is a combined *Facebook* Application and inline page integrated into the *OneStopPlus.com* website, whereby users create their model, dress up with 200 items from *OneStopPlus* brands, save their outfits to their closet, and share outfits with friends on *Facebook* to get the most votes⁶¹.

Overall, *MyModel.com*⁶² is a virtual mall operated by the '*Bauer Teen Network*' along with its 3 teen magazine properties: *Twist Magazine*, *J-14*, and *M*, whereby users create their model, dress up with garments selected by the editors of *Twist* and *J-14*, save their outfits to their closet, and share outfits on *Facebook*.

Furthermore, The *I-Fashion* project, developed in Korea, aims to commercialise virtual garments, which are fusion products of IT (Information Technology) and fashion, in the clothing industry. By applying 3D body scanning and 3D virtual simulation technologies, it provides services such as virtual coordination, virtual try-on, and electronic catalogues, and operates a system through which customers select and order products creating a

⁶⁰ <http://corpo.myvirtualmodel.com/index.html> (Accessed 19th April 2013)

⁶¹ <http://corpo.myvirtualmodel.com/gallery.html> (Accessed 19th April 2013)

⁶² <http://www.twistmagazine.com/?from=mymodel> (Accessed 19th April 2013)

new, service-centred and consumer-based marketplace, including all the elements of fashion trends.

Projects like *I-Fashion* and *LEAPFROG* – a European project, set up in 2004, with the objective to modernise and ultimately transform the European clothing sector into a flexible knowledge-driven high-tech industry, including partners like EURATEX (European Apparel And Textile Organisation), the Project Coordinator on behalf of AADLT (Association for the Advancement and Dissemination of LEAPFROG Technology), ATC (Athens Technology Centre), IFTH (Institute Francais Textile Habillement), DITF (Deutsche Institute fuer Textil und Faserforschung Denkendorf), MIRAlab, Hohenstein Institutes, etc⁶³ – are very important for the realization of mass customisation in the clothing industry as they go beyond automatic pattern generation (based on 3D scans) or flexible manufacturing technologies, but try to create an integrated platform where most of the traditional physical design, manufacturing, and sales processes are shifted to the digital domain (Huang, 2007)⁶⁴.

For this purpose, it is urgent to combine IT and fashion so that the fusion can create the apparel and fashion market toward the new values added of ‘*Service*’ and ‘*Mass Customisation*’. To concentrate the maximum competence on the achievement of this goal, in addition, it is necessary to strengthen the cooperation and liaison between the industries and universities⁶⁵.

So far, there are not many cases of application to apparel companies throughout the world, but because new market demand is being created and the need of 3D digital systems is being recognized, active development and use of such systems is expected in the near future. In order to activate the purchase of clothes through 3D virtual try-on

⁶³ <http://www.leapfrog-eu.org/> (Accessed 3rd March 2014)

⁶⁴ By Christine Huang on August 30th, 2007. In:

systems, accuracy of fit evaluation for virtual garments is very important. This, in turn, underlines the importance of technologies for generating virtual avatars that reflect the accurate body measurements and body shape of individuals, as well as technologies for trying virtual garments made by ‘made-to-measure’ patterns corresponding to individuals’ sizes (Lim & Istook, 2010:118-129).

6.4.2. Limitations of virtual Try-on Systems

A Lim and Istook study (2010), aiming to make virtual avatars and virtual garments using *OptiTex* and *V-Stitcher* virtual software, compared the appearance of virtual garments put on virtual avatars, created using body measurements obtained from five subjects of five different body shapes, using [TC]² body scanner. According to the results of this study, when different kinds of virtual software were used, the virtual avatars and virtual garments showed different appearance and fit. This may mean that when customers buy apparel products using different kinds of virtual try-on systems, their evaluation of appearance can vary depending on the virtual try-on system. Therefore, research needs to be made actively for the development and use of linkage programs that can reflect actual body measurements between virtual software systems and 3D body scanning systems (Lim & Istook, 2010:118-129).

6.5. A Case Study Comparison of Body Measuring Methods using manual and scanning technology

RATIONALE

The purpose of this case study was to evaluate the reliability and accuracy of body measurements extracted directly via the body scanner, compared to body

<http://www.psfk.com/2007/08/ifashion-virtual-shopping-in-south-korea.html> (Accessed 12th March 2012)

⁶⁵ <http://www.ifashion.or.kr/en/index.html> (Accessed 13th March 2012)

measurements taken manually, in order to determine the most appropriate method to use in this research.

Close-fitting clothing patterns reflecting the accurate information of the 3D body shape, especially of an asymmetrical body shape, has been one of the challenges for garment industry, while accurate 2D pattern, generated directly from 3D scan data, is essential for diverse applications (Kim *et al.*, 2010:142-146). Therefore, applying an auto-ethnographic approach in order to generate initial data for an experimental study, I was the subject of two body-scans by the '*TC² NX12 3D Body Scanner*' at the *London College of Fashion* premises.

Hence, this case study establishes the use of pattern engineering in order to develop basic pattern blocks for efficient and aesthetically pleasing functional garments, presenting techniques of pattern design and manipulation that can be used in order to find solutions to challenges posed by the specific anthropometry of a human body with scoliosis, incorporating together functional and aesthetic components.

Overall, a further aim of this case study was to prove that, in order to obtain reliable and accurate measurements of an individual's body, their body stance (posture) is a paramount factor and should remain the same during the whole procedure of measuring.

BACKGROUND

A 3D body scanner is an optical 3D measuring system to produce a digital copy of the surface geometry of human body by generating a very dense cloud of points (Vuruskan & Bulgun, 2011:47). The measurements possible with body scans are much more numerous and sophisticated than those taken with a tape measure; they are quicker, less intrusive, and can be more reliable, while body-scanning technology can be used to calculate circumferences, cross sectional slice areas, surface areas, and volumes (Loker *et al.*, 2005:1-15).

The [TC²]'s Nx12 body scanner system is a 3D measuring system, based on 'white light' technology and *Phase Mapping Profilometry* (PMP), scanning the whole body in approximately 8 seconds ([TC]², 2009) and produces approximately 140 body measurements with a 3D body model via point cloud data form. Eight cameras to capture the image and four laser light sources, similar to *Telmat's SYMCAD*, are used in order to project structured lines / patterns and to record xyz coordinate data from the surface of the scanned object. Data from the eight camera views are then transferred to a software package for processing, measuring, and displaying these data in three dimensions, while they are merged and re-triangulated, eliminating redundant points⁶⁶.

The [TC]² body scanners utilise white light technology, which simulates the triangulation of laser beams, but at a lower cost. [TC]²'s next generation scanner, the KX-16, breaks, for the time, the \$10,000 price with a full body coverage, full featured, changing-room sized, color commercial body scanning product with worldwide availability, utilizing technology from *Primesense Corporation*. The KX-16 represents a 20X reduction in price and a 10X reduction in size from [TC]²'s first body scanner (3T6), released in 1997, which was \$200,000 and required 200 square feet⁶⁷.

Nevertheless, apart from being rather high-priced for most retailers or apparel companies, during this case study, I discovered that certain patterns (i.e. sleeves) could not be extracted from TC² software⁶⁸, due to the fact that this particular software was still in progress in May 2008 and, in certain areas, still incomplete.

According to Song and Ashdown (2012), mass customization and automated custom clothing have been regarded as promising methods for the apparel industry to create

⁶⁶ Weathers, N. 2007. *Sizing up garment fit issues*. In:
In: http://www.just-style.com/analysis/sizing-up-garment-fit-issues_id98055.aspx (Accessed 23rd September 2011)

⁶⁷ <http://www.tc2.com/pdf/kx16%20pressrelease.pdf> (Accessed 13th December 2013)

well-fitting clothing for customers - nevertheless, current off-the-shelf automated custom patternmaking software cannot generate custom clothing with perfect fit, since alteration starts from a single graded base pattern, regardless of each customer's body shape, resulting in extreme pattern alterations in areas that the system cannot accomplish effectively for certain customers (Song & Ashdown, 2012:315).

Current research focuses on generating patterns that produce better fitting garments and 3D visualization tools to help fine tune style. Apparel patterns can be formed by either a 2D or 3D process, while often a combination of methods is used to create a pattern. Pattern Design Systems (PDS) have become invaluable tools to the patternmaker, assisting in much of the repetitive tasks associated with patternmaking, while PDS are also capable of storing an incredible amount of data that can be quickly retrieved, tweaked and re-filed. Some typical commercial software of 2D garment CAD are: *Gerber* in United States, *Investronica* in Spain, *Lectra* in France (Liu, Zhang & Yuen, 2010) and *PolyPattern* in Greece. Until recently, the most widely used PDS systems, like *Gerber*, *Investronica* and *Lectra*, were based on 2D patternmaking methods, unable to produce patterns based on 3D patternmaking processes, such as *draping*, whereby the pattern pieces are generated from a 3D form.

This study uses two different CAD systems of *PolyPattern* software (*PolyPatternDesign* and *PolyPatternM2M*).

METHODOLOGY

For this experimental study, the **first body scan** took place at LCF, in May 2008, during which I wasn't wearing my calliper⁶⁸ on, while the **second body scan** took place in June

⁶⁸ *TC² software* is the software used, in this research project, for producing patterns directly via scanning data.

⁶⁹ As mentioned earlier, ever since I had been attacked by the poliomyelitis virus, at the age of 3 months, I had to wear a calliper on my right leg, which supported my walking.

2008, during which I had my calliper on (Figure 6.1). My posture, strongly dependent on my calliper, appeared to be different during the two scans.

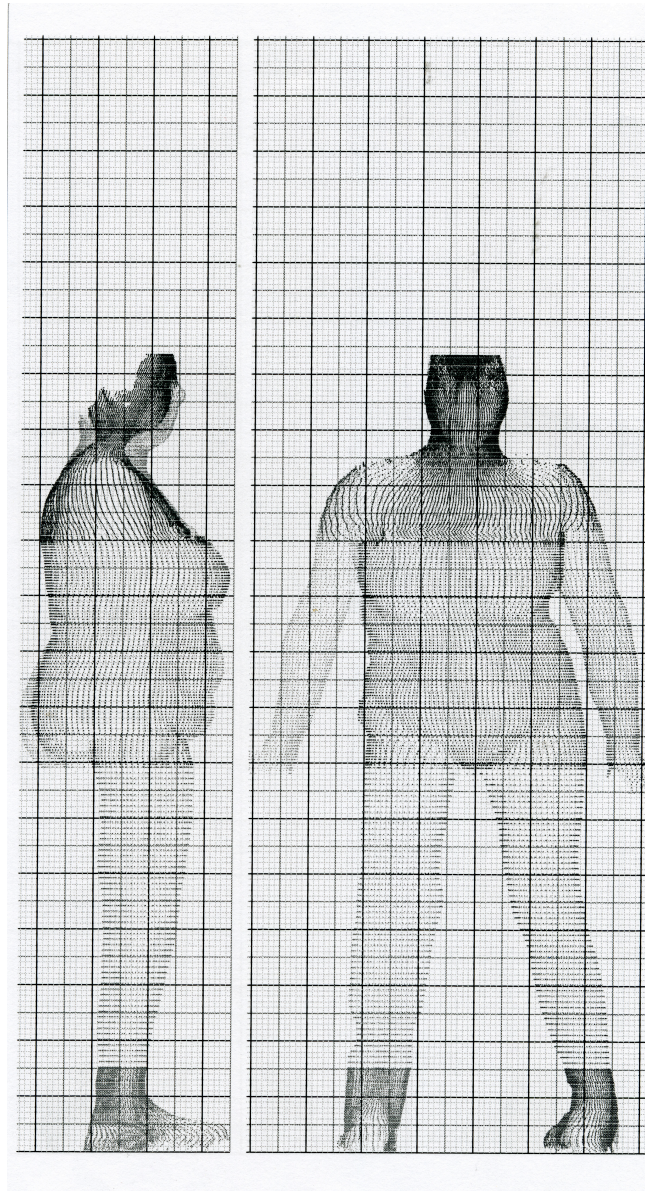


Figure 6.1 The researcher's body, scanned by the [TC]² NX12 3D Body Scanner

Table 6.1, below, indicates the shortest possible acronym that will be included in the text for ease of reading, i.e. Comparison 1-Toile1 becomes C1T1, Comparison 2-Toile 5 becomes C2T5, etc.

Table 6.1

Toiles	Toile 1 (Automatic patterns from Scan data)	Toile 2 (Manual patterns from Scan data)	Toile 3 (Manual data input to PolyPattern)	Toile 4 (Automatic patterns from Scan data)	Toile 5 (Automatic patterns from Scan data)	Toile 6 (Automatic patterns from Scan data)
1st Comparison (1 st Body Scan)	C1T1	C1T2	C1T3			
2nd Comparison (2 nd Body Scan)				C2T4	C2T5	C2T6
3rd Comparison (1 st & 2 nd Body Scans)	C3T1			C3T4		

The case study involved **three different sets of comparisons**:

- **The first comparison** involved *dress toiles* C1T1, C1T2 and C1T3, constructed after the first body scan, each using a different set of basic pattern blocks. The three toiles were compared in relation to five parameters (fit, movement, visual effect, comfort and feeling), as well as in terms of ease tolerance.
- **The second comparison** involved *trouser toiles* C2T5 and C2T6, constructed using pattern profiles derived directly via scanning, after the second body scan. The two toiles were compared in relation to five parameters (fit, movement, visual effect, comfort and feeling), as well as in terms of ease tolerance.
- **The third comparison** involved *dress toiles* C3T1 and C3T4, both made up using pattern profiles derived directly via scanning after the first and the second body-scan, respectively. The two toiles were compared in relation to five parameters (fit, movement, visual effect, comfort and feeling), as well as in terms of ease tolerance in relation to measurements.

6.5.1. The First Body Scan (May 2008)

After the first body scan, three different dress-toiles (C1T1, C1T2 and C1T3) were produced, based on my own body dimensions, each made up, using a different set of basic pattern blocks, described below. The comparison of the three toiles indicated that each construction method produced blocks with differing shapes and levels of ease, due to the fact that each method was based on a different measuring system.

C1T1

The pattern for dress-toile C1T1 was constructed using two separate patterns: the original *A3-Bodice* and *A3-Shiftskirt* patterns, which were automatically derived via scanning data (body measurements) from the *TC² system*, after the first scanning (Figure 6.2, see Table 6.2 - Appendix C for generated measurements and ease tolerances).

Unfortunately, there was no original *dress* pattern in the *TC² system*, while the sleeves of the original *A3-Bodice* could not be exported from the system, due to the fact that this particular software was still in progress, in May 2008, and in certain areas, still incomplete (Information provided by J. Bougourd, Senior Research Fellow at the London College of Fashion, University of the Arts London). Therefore, this dress pattern was left sleeveless.

Adjustments

The skirt and bodice waist darts didn't match, so a horizontal seam was needed at the waist level, in order to sew the front and back patterns of the dress together.

The front skirt pattern had to be taken in by 1cm, on each side of the waistline, so as to make it equal to the front bodice waist.

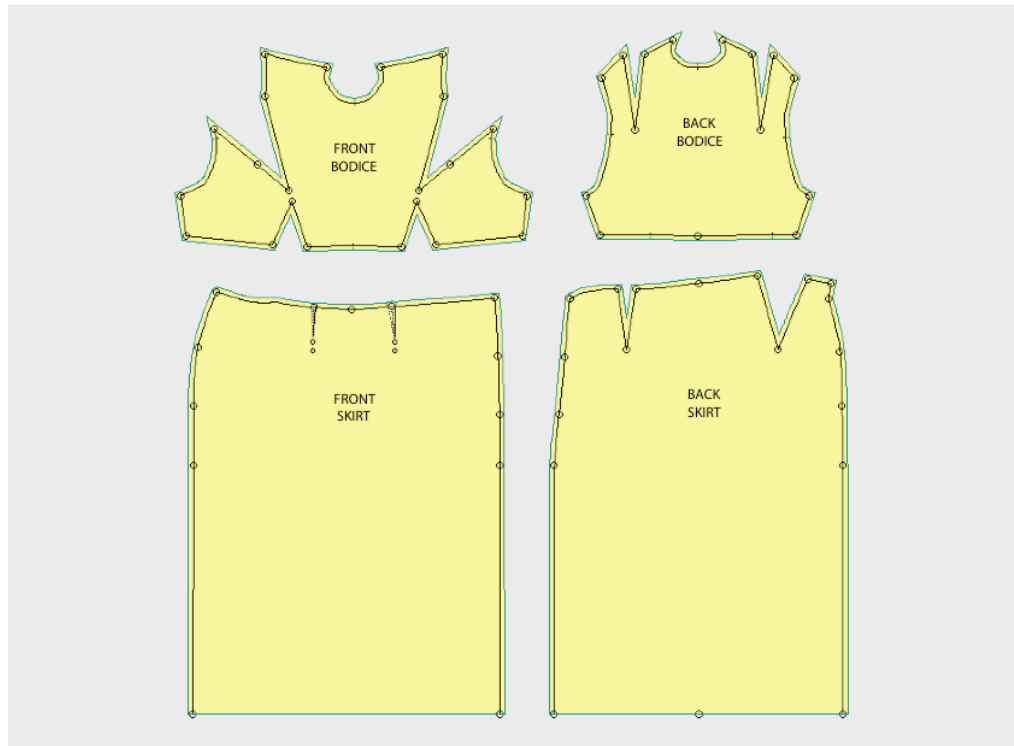


Figure 6.2. Pattern and Dress toile C1T1

The right-side dart of the back skirt had to be taken in by 2cm, on the waistline (1+1 on each side of the dart), while the left-side dart of the back skirt had to be taken in by 1cm, on the waistline (0.5+0.5 on each side of the dart), so as to make it equal to the back bodice waist.

Note: The horizontal waist seam was maintained in all three toiles of the first body-scan for better comparing results.

C1T2

C1T2 was generated from the basic close-fitting two-piece dress block (Aldrich, 1994:18-19 & 33-34) with one-piece narrow sleeves (Aldrich, 1994:26-27), for individual figures (Aldrich, 1994:36-37), in a CAD system called '*PolyPattern-Design 6.1V7*⁷⁰', based on measurements derived via scanning data from the *TC² system*, after the first scanning (Figure 6.4, see Table 6.3 - Appendix C for generated measurements and ease tolerances).

The drafting method applied was to follow the instructions for drafting the basic close-fitting two-piece dress block for individual figures, applying my own personal measurements, which were different for right and left side due to scoliosis, based on the first body scan.

According to this method, a series of numbered vertices, starting from 0 (zero) and guided by body dimensions and ease (ease was built-in the pattern 'blocks' and listed in Table 6.3 – Appendix C), are used to define the basic dress's pattern outline (Aldrich, 1994:18,19,26,27,33,34). This can be modelled in the form of a mathematical formula, relating to the placement of the numbered vertices (see Tables 8.2 & 8.3 – Appendix C),

⁷⁰ *PolyPattern* is a complete CAD system for pattern design, grading, and marking, which runs under Mac OS and Windows operating systems. It exchanges data with other systems via international standards, and communicates with most plotters, digitizers, cutters, databases, spreadsheets, software applications, and specialized machinery specific to the industry. In: <http://polytropon.com/en/index.html> (Accessed 14th April 2008)

while critical vertices are usually related to the human girth measurements of the bust (i.e. vertices 2-3), waist (i.e. vertices 5-6), hips (i.e. vertices 7-8), etc (Figure 6.3).

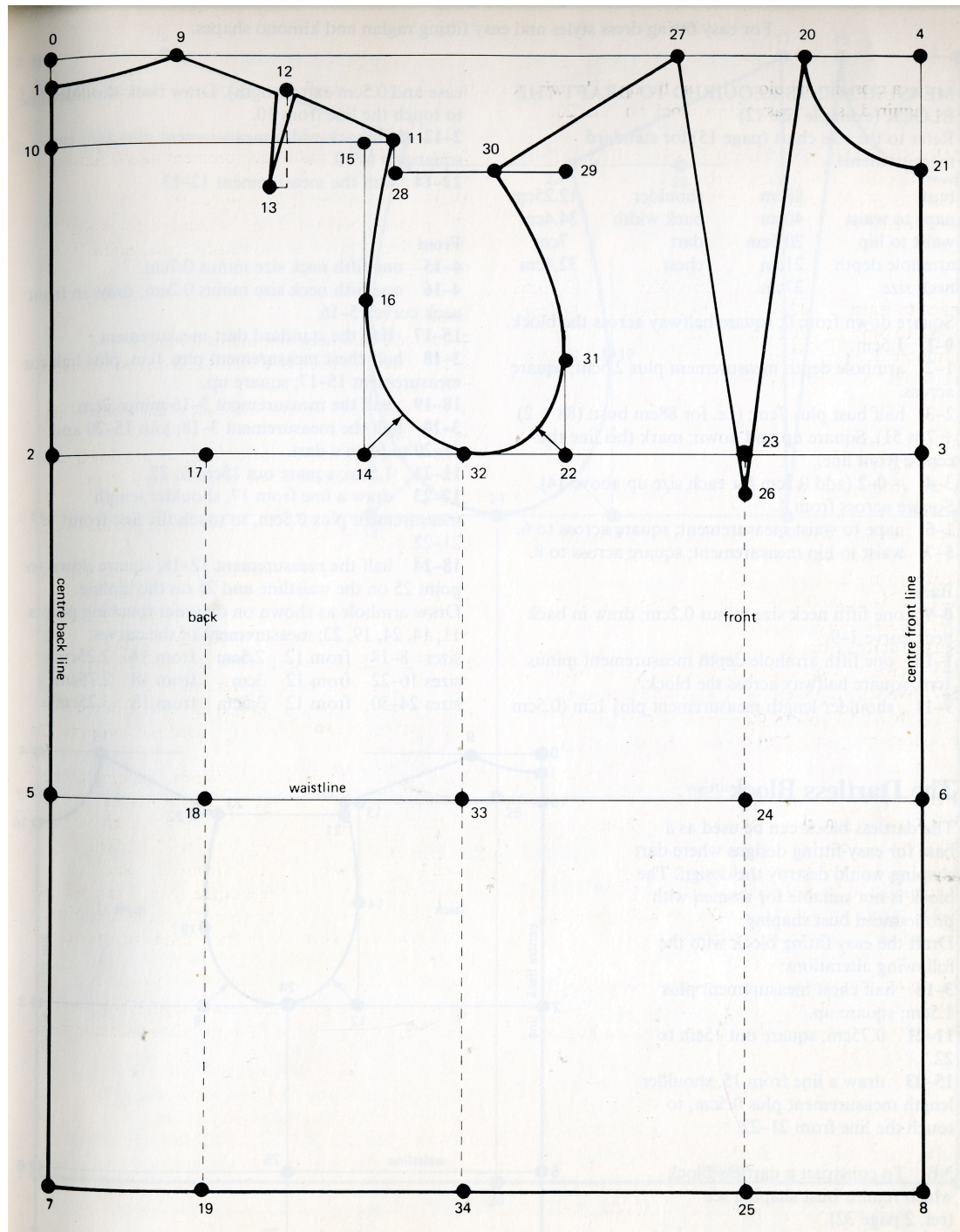


Figure 6.3. The close-fitting bodice block (Aldrich, 1994:18-19)

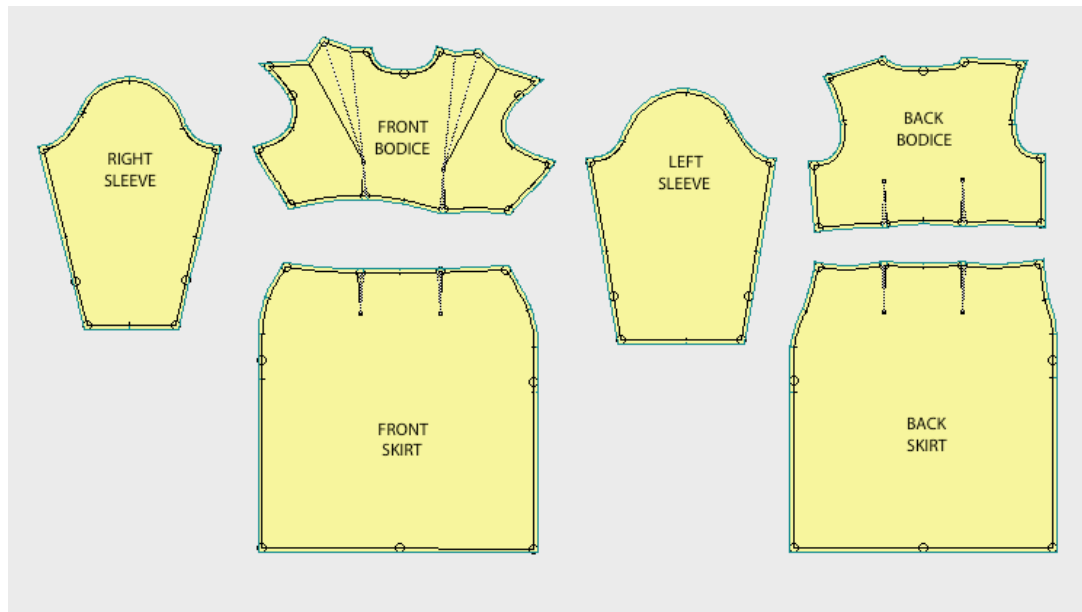
Adjustments:

Certain measurements, derived from the scanning data, such as the right armscye girth (33.81cm) and the left armscye girth (37.85cm), couldn't possibly fit my arms. After obtaining these two particular measurements manually, it was found that they were 51cm and 54cm, respectively. Hence, the right armscye girth had to increase by 8.6cm front and back, while the left armscye by 8.0cm front and back. A significant difference (13.29cm) was also found between the lengths of the right arm (39.04cm) and the left arm (25.75cm), which didn't comply with the appearance of my arms. After obtaining these two particular measurements manually, it was found that they were 56cm and 57cm, respectively. Hence, the right arm had to be lengthened by 16.96cm, while the left arm by 31.25cm.

C1T3

C1T3 was derived from the basic two-piece dress block (Aldrich, 1994:18-19 & 33-34) with one-piece narrow sleeves (Aldrich, 1994:26-27), made up using pattern profiles designed manually, in a CAD system called *Polypattern-Design 6.1V7*, based on measurements also obtained manually (Figure 6.5, see Table 6.4 - Appendix C for measurements and ease tolerances, determined by myself).

The measurements taken from myself, for constructing C1T3 were used for drafting a basic dress block for individual figures (Aldrich, 1994:36-37). The drafting method applied was the same as for C1T2 (Aldrich, 1994:36-37) - following the instructions for the basic close-fitting two-piece dress block with one-piece narrow sleeves (ease was built-in the block) (Aldrich, 1994: 18,19,26,27,33,34), using my own personal measurements, which were different for right and left side due to scoliosis, and applying them for adapting the **size 18 UK** basic dress block (since **size 18 UK** is my standard size, according to Aldrich's size chart: Aldrich, 1994:15, see Table 6.5, p.189).



TOILE 2



Figure 6.4. Pattern and Dress toile C1T2

Table 6.5⁷¹

BODY MEASUREMENTS	PERSONAL MEASUREMENTS LEFT RIGHT		STANDARD MEASUREMENTS for SIZE 18 UK	COMMENTS ON FIGURE
1. BUST	103		102	LARGER
2. WAIST	84.5		82	LARGER
3. HIPS	109		107	LARGER
4. BACK WIDTH	38		37.8	LARGER
5. CHEST	37		36.5	LARGER
6. SHOULDER	11.5	12.5	13.1	NARROWER
7. NECK SIZE	39.5		40.4	SMALLER
8. DART	8.8		8.8	
9. TOP ARM	34	30	32.8	LARGER / SMALLER
10. WRIST	18	16.5	17.5	LARGER / SMALLER
11. NAPE TO WAIST	35		41.5	SHORTER
12. FRONT SHOULDER TO WAIST	46	45	42.1	LONGER
13. ARMHOLE DEPTH	22.5		22.5	
14. SKIRT LENGTH	69.5	68.5		
15. WAIST TO HIP	21.5		21.5	
16. WAIST TO FLOOR (C.B.)	98		107	SHORTER
17. BODY RISE	23	20	30.1	SHORTER
18. SLEEVE LENGTH	57	56.5	60	SHORTER

⁷¹ Measurements 8, 13 and 15 (in regular font) are standard measurements according to Aldrich's size chart for size 18 UK (Aldrich, 1994:15)

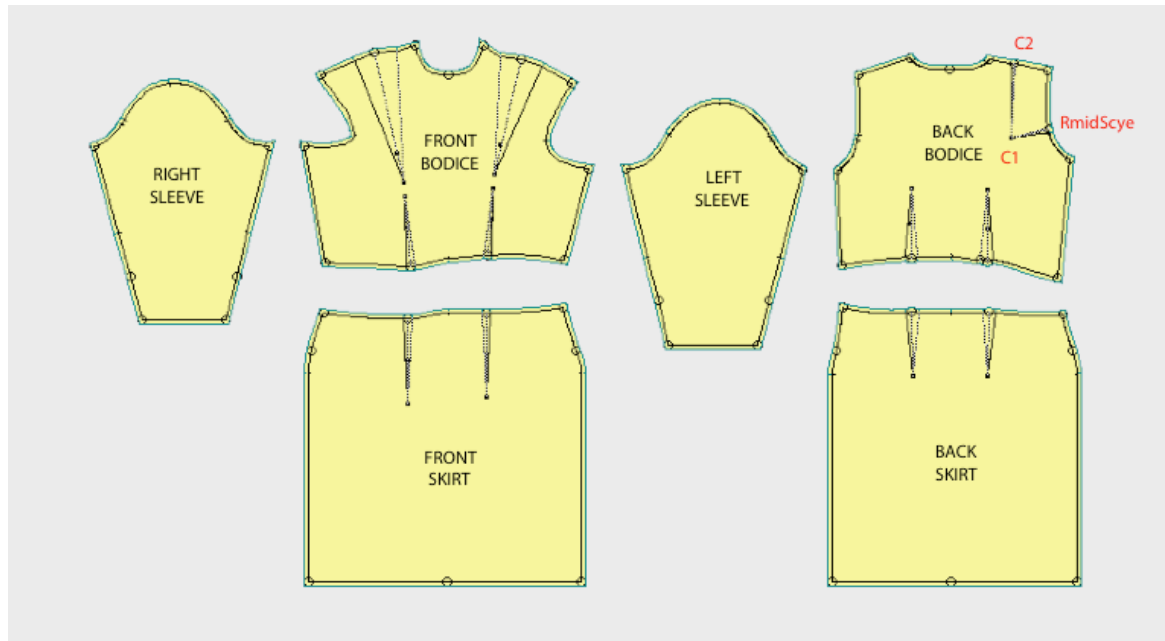


Figure 6.5. Pattern and Dress toile C1T3

Adjustments:

I have a 43-degree prominent curvature due to thoraco-lumbar scoliosis of the spine, at the right back side of my body. To accommodate this curvature of my spine, a dart was needed on the right back dress pattern block (C1T3), in order to achieve the best garment fit in that area.

Pattern Engineering

Shaping the human body form refers to two main areas: the *body contour* and the *body volume*. For instance, the shape on the side of the body is obtained by shaping the side seam of the garment pattern, in order to bring the garment closer to the body contour on the side. Likewise, the volume (3D shape) of the human body, at the front, is usually around the bust and the waist, whereas at the back, it is around the shoulder blades (scapulae). Shaping is more prominent in women's bodies and is achieved by various 'darts' - by folding in the excess of fabric in certain areas – that can be manipulated all around the pattern blocks (Anand, 2011:358). On the other hand, apparel pattern design for individuals with scoliosis of the spine requires attention to the bodily changes resulting from this spinal deformity, while incorporating functional adjustment, which would make garments more comfortable, adapt to any limitations in movement and enhance their confidence. In the case of an individual with an asymmetric spine, due to scoliosis, the volume of their body form exists also around the formulated hump, due to scoliosis, the shaping of which can be achieved by a dart (Figure 6.6).

As mentioned in Chapter 2.3, **the most common types of scoliosis are Thoracic (C-type) and Thoraco-lumbar (S-type). 90% of the thoracic curves are right convexity (C-type curve to the right), while 80% of the thoraco-lumbar curves are also right convexity (S-type curve to the right)** (Information provided by the official 'Massachusetts General Hospital' website). Hence, **in both common types, a prominent scoliotic**

curve is formed usually at the right side, at the thoracic segment (upper back and thorax), which consists of 12 vertebrae (Anderson, 2007:44-65).

Therefore, a dart at the mid-back region on the back bodice or dress block, on the scoliotic curve's side, could be incorporated providing additional fabric to fit the protruding curvature. This dart would make the final garment more comfortable for the wearer providing ease of movement, while bending, turning, stooping, or any activity, that may exert extra pressure across the back. It should start 1-1.5 cm away from (and around) the scoliotic curve's actual peak point (Landmark C1) and should end vertically straight up, upon the shoulder line (Landmark C2) (Hernandez, 2000:53-54).

For a better shaping and a more aesthetically pleasing result, it could then be manipulated and transferred, by 100%, to the back midscye (MidB), on the scoliotic curve's side (i.e. at the right midscye if the individual had a right thoracic or thoracolumbar scoliosis - RMidB), since the curve, in such cases, almost always occurs around the thorax level. Figure 6.5 shows the pattern modifications on the right back pattern block, so as to achieve the desired feature.

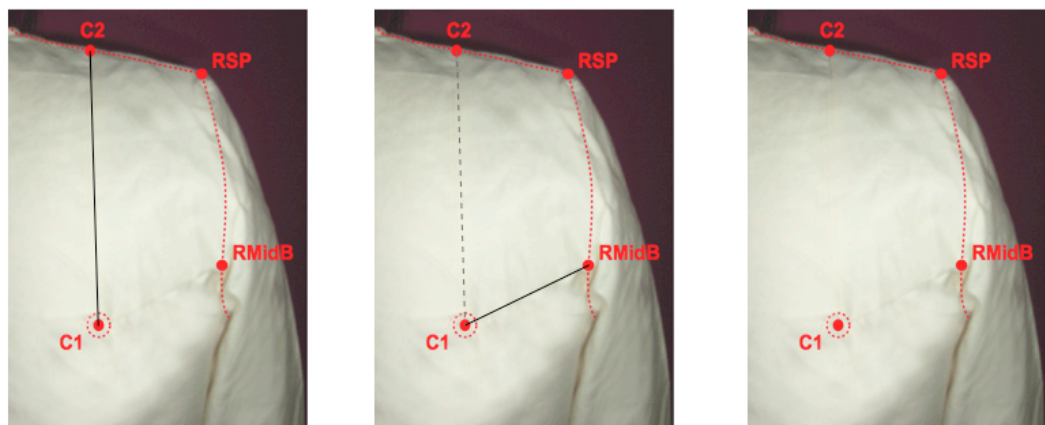


Figure 6.6. Shaping the scoliotic curve by a dart starting at landmark C1 (Toile C1T3)

The width of the Right Back Shoulder Dart, starting at Landmark **C1** and ending at Landmark **C2**, is calculated by the following formula (Appendix C, Tables 8.4 & 8.5):

Right Back High Bust Width [Minus] Right Half Across Back

Hence, it is obvious that some extra measurements had to be included to the compilation of the measurement set, used for measuring girls with scoliosis (Meas. 54b, 54c – Chapter 7.3.3), in order to define the location of landmarks C1 and C2, which determine the shape and size of a scoliotic curve and are needed for achieving a better fit around the curve area (Hernandez, 2000:46).

COMPARING C1T1, C1T2 & C1T3 IN TERMS OF FIT, MOVEMENT, VISUAL EFFECT, COMFORT AND FEELING

The first three *dress-toiles* (C1T1, C1T2 and C1T3) were compared, despite the fact that C1T1 was sleeveless (by me, as the researcher), in terms of fit, whereby fit images were sectioned into zones (neckline, shoulders, bust, etc.), in order to facilitate the compilation of a table (Table 6.6a - Appendix C) from the fit assessment matrix, to provide a more qualitative comparative evaluation.

The three *dress-toiles* were also compared in relation to four extra parameters and were rated with an average numeric assessment from 1 to 4 (Table 6.6b, below), for each of the following:

- Fit
- Movement
- Visual effect
- Comfort
- Feeling

Table 6.6b

TOILES	C1T1		C1T2		C1T3	
FIT	MODERATE	3	UNSATISFACTORY	1	SATISFACTORY	4
MOVEMENT	MINOR PROBLEMS	2	SATISFACTORY	4	MODERATE	3
VISUAL EFFECT	MODERATE	3	UNSATISFACTORY	1	MINOR PROBLEMS	2
COMFORT	MINOR PROBLEMS	2	MODERATE	3	SATISFACTORY	4
FEELING	MINOR PROBLEMS	2	UNSATISFACTORY	1	SATISFACTORY	4
AVERAGE RATINGS	2.4		2		3.4	

C1T1 and C1T2 were found quite large in the waist area, while both garments' waistlines were positioned much higher than my natural waistline. C1T3 was found quite tight in the waist and high hip area, while the garment's waistline was positioned exactly at my natural waist level. Unfortunately, tight waist caused a minor difficulty in movement for me, although C1T3 appeared to have the best fit, embracing the body gracefully.

C1T1 was quite tight in the under-bust area, causing a minor discomfort in breathing and difficulty in movement, while C1T2 had enough allowance all around the body, providing adequate freedom for movement.

In terms of visual effect, C1T1 had the best appearance, although it was difficult to compare with the other two, since this dress-toile was sleeveless. C1T3 had a moderate appearance, due to the close-fitted waist area, although the visual effect of the sleeves was more than satisfactory. C1T2 had a poor appearance, owing to the fact that the right side seam from waist to hem 'pulled' the garment towards the front, while the left side seam from waist to hem 'pulled' the garment towards the back. The scoliotic curve, on

the right-back side, created creases under the left shoulder blade, 'lifting up' the left back hem.

C1T1 and C1T3 seemed to be quite comfortable, although they were fairly tight in certain areas. C1T2 was the least comfortable garment with the worst appearance.

I felt best in C1T1 and C1T3, probably owing to their excellent physical sensation all around the body, while C1T2 felt much better around the scoliotic curve.

In conclusion, pattern profiles generated directly by scanning data (C1T1) provided a moderate fit and appearance, having minor problems regarding movement, comfort and feeling, with an average rating of 2.4. Pattern profiles designed manually, based on measurements derived directly by scanning data (C1T2), were far from giving a perfect fit or appearance, while comfort and feeling needs were not met, and only movement was satisfactory, with an average rating of 2. Overall, pattern profiles designed manually via software, based on measurements taken manually (C1T3), provided the best fit, comfort and feeling, among the three toiles, having a fairly satisfactory appearance and minor problems in movement, with an average rating of 3.4.

COMPARING C1T1, C1T2 & C1T3 IN TERMS OF EASE TOLERANCE, IN RELATION TO MEASUREMENTS

Tables 6.2, 6.3 and 6.4 (Appendix C) indicate the ease tolerances used for designing the pattern blocks for C1T1, C1T2 and C1T3, respectively, which were constructed after the first body scan.

C1T1 and C1T2 measurements were both derived directly via scanning. The difference between making up the two toiles was that C1T1 ease tolerances were also derived automatically via scanning, owing to the fact that the pattern blocks were exported directly from *TC² Software*, while C1T2 ease tolerances were estimated by me (Table 6.3

– Appendix C). Body measurements for C1T3 were taken manually, by my assistant, while ease tolerances were estimated by me (Table 6.4 – Appendix C).

As it is very difficult to compare toiles, based on sets of measurements obtained completely differently, (C1T1 and C1T2 automatically, whereas C1T3 manually), the first two toiles were initially compared separately, and then, they were both compared in relation to C1T3. Therefore, a comparison between ease tolerances, in relation to measurements, would be more appropriate in this case.

On the one hand, it is evident from Tables 6.2 and 6.3 (Appendix C) that C1T1 and C1T2 were made up using similar amounts of tolerance, with the exception of certain measurements, where the tolerance difference exceeded 4cm. The largest amount of tolerance in C1T1 was 20.65cm, concerning the right armscye girth, while the largest amount of tolerance in C1T2 was 33.75cm, concerning the left arm length straight. On the other hand, Table 6.4 indicates that the largest amount of tolerance in C1T3 was found in the distance from the right side neck to waist straight and didn't exceed 17cm (16.71cm).

Overall, the most significant tolerance differences were noted in the right side waist to hip area (13.51cm), while the least tolerance difference was noted in the front hip girth – C1T2 being the larger by only 0.01cm. It is also worth mentioning that the only pattern measurement, where there wasn't any tolerance difference between the first two toiles, was the front neck to waist distance, while C1T3 was found 4.98cm longer than both the other two. Moreover, Tables 6.2, 6.3 & 6.4 (Appendix C) show that the three toiles did not have the same amount of tolerance in any of the measurements.

6.5.2. The Second Body Scan (June 2008)

After the second body scan, three different toiles (C2T4, C2T5 and C2T6) were produced based on my own body dimensions: a basic dress with one-piece long narrow sleeves, a pair of baggy trousers and a pair of classic-cut trousers. All three toiles were constructed using different tolerances around the body, owing to the fact that each one of them represented a different garment style.

C2T4

The pattern for dress toile C2T4 was constructed using the original *T_{c1}-Bodice* and *T_{c1}-ASkirt* patterns, derived directly via scanning data from the second body scan by *TC² NX12 3D Body Scanner* done on me (Figure 6.7, see Table 6.7 - Appendix C for generated measurements and ease tolerances).

Apparently, one month after the 1st body scan (May 2008), the sleeve patterns could be finally exported from TC² software, although the software was still in progress, in June 2008, and in certain areas, still incomplete (Information provided by J. Bougourd, Senior Research Fellow at the London College of Fashion, University of the Arts London). Notwithstanding, the bodice was very tight in the chest, shoulder and sleeve area, although it gave an excellent fit around the bust area. Moreover, it was so tight at the back that I couldn't move my arms or turn around, which resulted in tearing the centre-back zip apart.

Adjustments:

The skirt and bodice waist darts didn't match, so a horizontal waist seam was needed in C2T4, as in C1T1, C1T2 and C1T3, in order to sew the front and back patterns of the dress together.

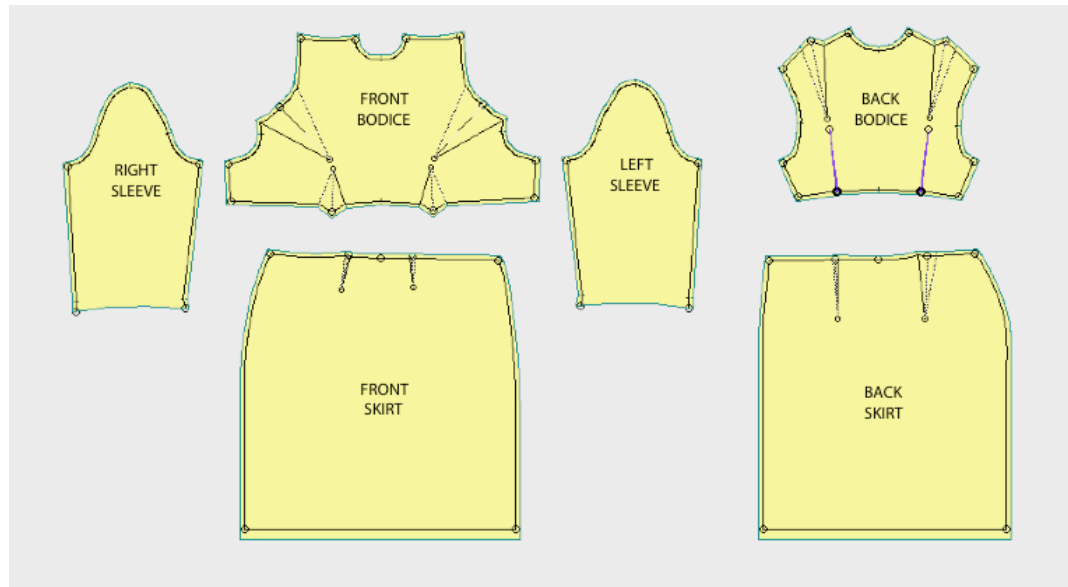


Figure 6.7. Pattern and Dress toile C2T4

C2T5

C2T5 was a pair of baggy trousers, made up using pattern profiles that were generated directly by scanning data, from the second body scan, by *TC² NX12 3D Body Scanner*, done on me (Figure 6.8, Table 6.8 - Appendix C). The pattern for this pair of trousers was constructed using the original *T_c3-Pants_Smallest* pattern, derived directly via scanning.

C2T6

C2T6 was a pair of classic-cut trousers, made up using pattern profiles generated directly by scanning data from the second body scan, by *TC² NX12 3D Body Scanner* done on me (Figure 6.9, Table 6.9 - Appendix C). The pattern for this pair of trousers was constructed using the original *T_c1-SWPants* pattern, derived directly via scanning.

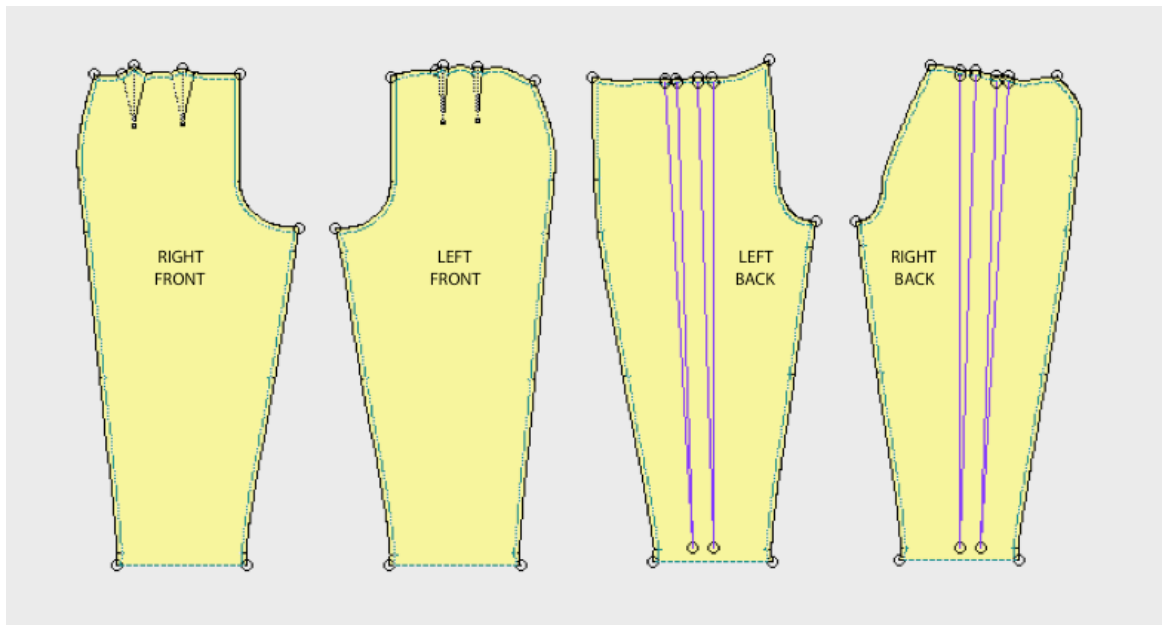


Figure 6.8. Pattern and Trouser toile C2T5

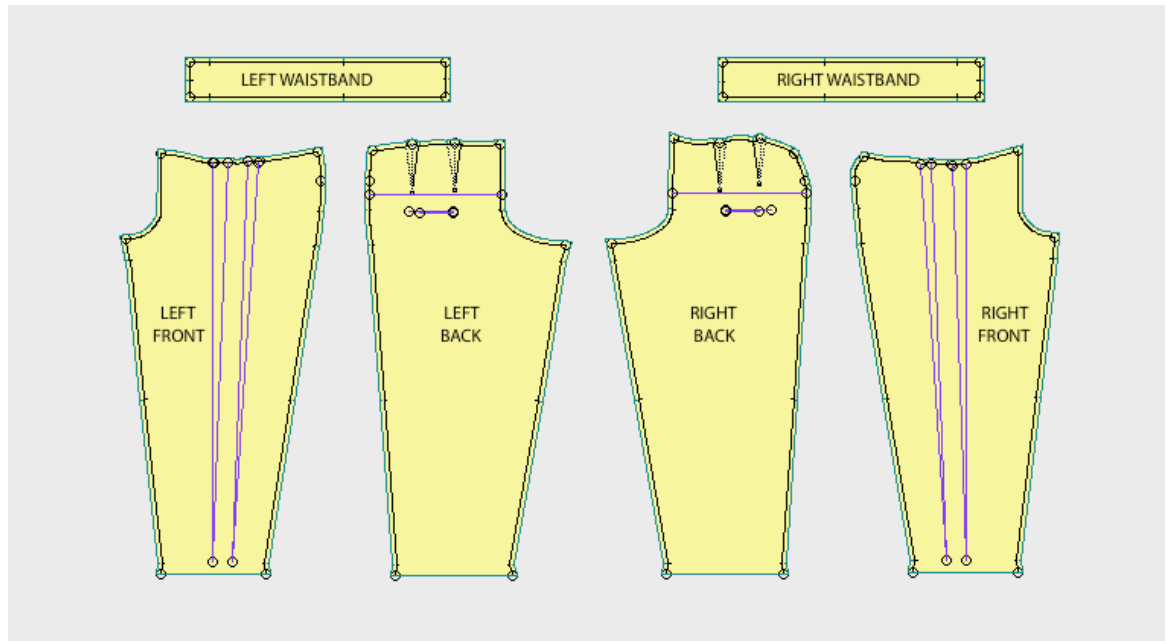


Figure 6.9. Pattern and Trouser toile C2T6

COMPARING C2T5 & C2T6 IN TERMS OF FIT, MOVEMENT, VISUAL EFFECT, COMFORT AND FEELING

The two trouser toiles (C2T5 & C2T6) were compared in terms of fit (by me, as the researcher), whereby fit images were sectioned into zones (waist, hips, crotch, etc.), in order to facilitate the compilation of a Table (Table 6.10a - Appendix C) from the fit assessment matrix, to provide a more qualitative comparative analysis. The two trouser toiles were also compared in relation to four extra parameters and were rated with a numeric assessment from 1 to 4 (Table 6.10b, below), for each of the following:

- Fit
- Movement
- Visual effect
- Comfort
- Feeling

C2T5 did not have a waistband and was extra baggy, especially on the left side, creating a *hump* around the left hip area, while C2T6 had a 4cm-wide waistband all-around, were not baggy and looked much more aesthetically pleasing. C2T6 also had a much better fit than C2T5, probably owing to the waistband, which provided a smooth and sleek result, without any bulks around the waist area.

The excess of fabric around the left hip area of C2T5 caused minor problems in walking and movement, in general, and wasn't very comfortable - it made me feel rather uneasy. On the contrary, C2T6 provided quite satisfactory movement and comfort, making me feel more confident in them. In conclusion, C2T6 was a far more satisfactory pair of trousers than C2T5, with a double average fit rating (C2T6: 3.6 versus C2T5: 1.8).

Table 6.10b

TOILES	C2T5		C2T6	
FIT	UNSATISFACTORY	1	MODERATE	3
MOVEMENT	MINOR PROBLEMS	2	SATISFACTORY	4
VISUAL EFFECT	UNSATISFACTORY	1	SATISFACTORY	4
COMFORT	MINOR PROBLEMS	2	MODERATE	3
FEELING	MODERATE	3	SATISFACTORY	4
AVERAGE RATINGS		1.8		3.6

COMPARING C2T5 & C2T6 IN TERMS OF EASE TOLERANCE

Tables 6.8 and 6.9 (Appendix C) indicate the ease tolerances used for designing the pattern blocks for C2T5, and C2T6, respectively, which were made up after the second body scan. C2T5 and C2T6 measurements were both derived directly via scanning and their ease tolerances were also derived automatically via scanning, due to the fact that the pattern blocks were exported directly from *TC² Software*.

The two Tables (6.8 & 6.9 – Appendix C) show that C2T5 and C2T6 were made up using similar amounts of ease tolerance, with the exception of certain measurements where the ease tolerance difference exceeded the 4cm - C2T6 appearing to have more ease tolerance in most cases.

The only three cases where C2T5 ease tolerances exceeded those of C2T6 were the front waist girth, the front hip girth and the total hip girth, the latter demonstrating a tolerance difference of approximately 30cm (29.7cm).

In general, there were only four cases where there wasn't any tolerance difference between C2T5 and C2T6. These were both, the right and left ankle girths, as well as both, the right and left long heel girths.

6.5.3. Comparing the two Body Scans

MEASUREMENT FLUCTUATIONS BETWEEN THE TWO BODY SCANS

Table 6.11 (Appendix C) shows the decrease or increment (in cm) of the same measurements between the two body scans, as well as the percental (%) difference between them.

It is evident from this table that there are certain worth-noting fluctuations, mainly concerning height and vertical measurements, ranging from 0.16% (left armscye height) to -487.10%⁷² (left armscye depth).

Table 6.11 also indicates rather steep fluctuations concerning the arms and the shoulders, between right and left side: On the one hand, the left underarm length had been increased by 55.51%, whereas the right only by 4.44%. The left arm length straight also showed an increment of 105.59%, whereas the right only of 28.30%. Furthermore, the left centre back to elbow had a rise of 46.39%, while the right only of 5.77%.

On the other hand, the right long shoulder length had been reduced by 17.80%, whereas the left by 43.41%, while the right armscye width calliper had been increased by 53.05%, whereas the left only by 2.69%. In addition, the right long shoulder slope had been increased by 356.25%, while the left only by 2.74%.

On the contrary, both crown heights had been increased by over 180%: the right crown height had increased 8.16cm (185.03%) and the left 7.39cm (188.52%).

⁷² The negative value indicates that there has been an increment in the same measurement between the two body scans, while the positive value indicates a decrease in the same measurement.

The front shoulder width had decreased 14.23 cm (25.82%), while the back neck to blades horizontal WI had decreased by 37.43% and the back neck to blades horizontal WO by 30.26%.

The right bust to waist had been increased by 47.34%, whereas the left only by 27.60%. Concurrently, the abdomen height from waist had been reduced by 4cm (34.78%), while the back seat angle decreased 11.59cm (32.97%).

The right side waist to hip decreased by 30.51%, while the right side waist to seat by 29.36%. On the contrary, the left side waist to hip had been reduced by 29.20%, while the left side waist to seat by 32.24%.

Relative differences were noted in both, the left and right leg measurements:

The right minimum leg height increased 1.92cm, whereas the left 2.67cm. Meanwhile, the right ankle height inside had shown an increase of 14.81%, whereas the left had been increased even more (25%).

Overall, the torso slice file was found reduced by 30.76%, a rather noticeable percentage, while the remaining measurements demonstrated less significant fluctuations (under 15%), which are not worth further analysing. This was rather expected, due to the fact that during the second scan I was wearing my callipers on. It was worth doing the comparison between body measurements obtained after the two scans, however, in order to test the accuracy of the measurement-obtaining scanning method.

COMPARING C3T1 & C3T4 IN TERMS OF FIT, MOVEMENT, VISUAL EFFECT, COMFORT AND FEELING

As mentioned earlier, C1T1 was a sleeveless basic dress, made up using bodice and skirt pattern profiles generated directly by scanning data from the first body scan (May 2008), while C2T4 was a long-sleeve basic dress, made up using bodice and skirt pattern profiles generated directly by scanning data from the second body scan (June 2008). The 3rd stage of this experimental study involved the comparison of the two dress-toiles, produced after the two body-scans (C1T1 becomes C3T1 and C2T4 becomes C3T4 – see Table 6.1, Chapter 6.5:177).

Hence, C3T1 and C3T4 were compared in terms of fit, whereby fit images were sectioned into zones (neckline, shoulders, bust, etc.), in order to facilitate the compilation of a table (Table 6.12a - Appendix C) from the fit assessment matrix, to provide a more qualitative comparative analysis.

Moreover, the two dress-toiles were also compared, in relation to four extra parameters, and were rated with a numeric assessment from 1 to 4 (Table 6.12b, below), for each of the following:

- Fit
- Movement
- Visual effect
- Comfort
- Feeling

On the one hand, C3T1 was much more comfortable and I felt much better in it, due to the fact that I was able to move freely, without any movement limitations, since it was sleeveless. On the other hand, C3T4 provided a moderate feeling of comfort for me, while having serious problems in movement and fit, since it was quite small in the

shoulder and sleeve areas, and too tight around the waist, resulting in tearing the centre-back zip apart. C3T4, however, provided a much better aesthetic outward appearance, due to the close-to-the-body waist and hip area, whereas C3T1 was quite large in the high-hip and hip area, providing an unsatisfactory fit and a poor visual effect.

In conclusion, both C3T1 and C3T4 were found to demonstrate equal average fit ratings (both of 2.4), concerning the above five different parameters, indicating that despite the difference in my posture, which, consequently, provided different body measurements derived from the two body scans, both dress toiles (C3T1 and C3T4) were found to provide a fit with minor problems.

Table 6.12b

TOILES	C3T1		C3T4	
FIT	MODERATE	3	UNSATISFACTORY	1
MOVEMENT	MINOR PROBLEMS	2	UNSATISFACTORY	1
VISUAL EFFECT	MODERATE	3	SATISFACTORY	4
COMFORT	MINOR PROBLEMS	2	MODERATE	3
FEELING	MINOR PROBLEMS	2	MODERATE	3
AVERAGE RATINGS	2.4		2.4	

COMPARING C3T1 & C3T4 IN TERMS OF EASE TOLERANCES IN RELATION TO MEASUREMENTS

Tables 6.2 and 6.7 (Appendix C) indicate the ease tolerances used for designing the patterns C3T1 & C3T4, which were constructed after the first and the second body scan, respectively. Measurements for both toiles were derived via scanning and their tolerances were also derived automatically via scanning, due to the fact that all pattern blocks were exported directly from *TC² Software*.

A quite important factor, however, that needs to be taken into serious consideration for the following comparison, is the numerical difference between most of the measurements during the two scans. Consequently, the tolerances were bound to be different, thus, a comparison between ease tolerances, in relation to measurements, would be more appropriate in this case.

Wherever there were significant measurement differences, the tolerances should also demonstrate significant difference. Hence, the most significant tolerance difference concerned the right armscye girth measurement, where C3T1 tolerance exceeded that of C3T4 by 18.4cm, due to the fact that C3T1 right armscye girth was 16.16cm smaller than that of C3T4.

On the one hand, the largest amount of ease tolerance used in the construction of C3T1 was noted in the right armscye girth, whereas it was in the front underbust girth for C3T4. C3T1 front underbust girth was found to have less than half the ease tolerance of that of C3T4.

On the other hand, the least tolerance amount for both toiles was noted in the chest girth, where C3T4 was 26.72cm smaller than its actual measurement, while C3T1 was

16.72cm smaller than its actual measurement. It is also worth mentioning that C3T1 chest girth was only 4.37cm larger than that of C3T4.

Furthermore, both C3T4 right and left centre side waist to hip had less than half the tolerance of C3T1 right and left centre side waist to hip, respectively. Concurrently, both C3T1 right and left side waist-to-hip had almost the double tolerance of C3T4 right and left side waist-to-hip, respectively. What is quite peculiar, is that C3T1 bust girth and upper hip girth demonstrated more than twice as much tolerance as C3T4 bust girth and upper hip girth, respectively, while those two particular measurements were found almost the same after the two scans.

Finally, C3T4 demonstrated a zero rate of ease tolerance in more than five measurements, while C3T1 was found to have zero ease tolerance only in the distance between the right front shoulder-point to the centre front waist.

Overall, the two tables (6.2 & 6.7 – Appendix C) show that C3T1 and C3T4 were made up using similar amounts of ease tolerance, in most cases, with the exception of certain measurements where the ease tolerance difference exceeded 6cm - C3T1 appearing to have more tolerance in almost all cases.

6.5.4. Conclusions

The case study comparison on manual and scanning methods of body measuring indicated that the dress toile C1T3, made up using pattern profiles designed manually, assembled the highest average fit rating (3.4), compared to the other three dress toiles (C1T1, C1T2 and C2T4), all made up using pattern profiles generated directly by scanning data from the two body scans by *TC² NX12 3D Body Scanner*, with average fit ratings of 2.4, 2 and 2.4, respectively. Moreover, it was found that the measurement set obtained by the *TC² NX12 3D Body Scanner*, after the first body scan, was not 100%

reliable (see arm length and armscye measurements, Tables 6.2 & 6.3 - Appendix C), while it provided a *fit with minor problems* (average fit ratings: 2.4 and 2, respectively) for both dress toiles (C1T1 & C1T2). On the contrary, the measurement set obtained manually by me (Table 6.5, Chapter 6.5.1) provided a dress toile (C1T3) with a *moderate to satisfactory* fit (average fit rating: 3.4). Hence, the most appropriate method for measuring the subjects' bodies, for this research, would be the manual measurement-obtaining method, using a tape measure and a set ruler, although I expected that the scanning method would be much more accurate, in terms of accuracy of the measurement-obtaining procedure.

In addition, this study also proved that a change in my posture (with and without wearing callipers) did, actually, have a considerable impact on my body measurements, presenting different values in each body scan. Hence, the five different parameters concerning the behaviour of a garment - fit, movement, visual effect, comfort and feeling - are strongly associated with an individual's posture when the specific individual is being measured. In addition, the ease tolerances used in the construction of a garment, definitely, influence all of the above.

Overall, as Hernandez has also pointed out, in order to obtain precise and accurate measurements from an individual with scoliosis, certain extra measurements, concerning the location and size of the scoliotic curve, are needed to achieve the best fit of a garment, constructed for such individuals (Figure 6.6) (Hernandez, 2000:46). The value of these extra measurements formed the core of this research study, implemented in the selection of asymmetric basic blocks as *base sets* input in the *PolyPatternM2M* software, in order to draft basic 'blocks' for adolescent females with scoliosis.

Chapter 7

Figure Analysis of a body with Scoliosis based on the Measurement Set compiled for this research – Subject Classification and Size Chart Development for the two most populated Scoliotic Groups

7.1. The Landmarks

Researchers have been interested in *body shape* for many years and have employed many methods, including somatotyping and somatometry, using devices such as callipers or shoulder-angle measuring devices and body-scanning, in order to classify body shapes (Chen, 2011:302) and measure the body in an effort to capture its dimensions for clothing.

According to Vincent (1893) there are certain movements of the limbs and certain positions of the skeleton or framework which always remain near the surface - i.e. in a thin woman the bones may be felt very plainly at these places, and, no matter how fat the person may become, these particular parts are still only covered by a comparatively thin portion of skin, as compared with the other parts of the body (Vincent, 1893-1898:2). Thus, no matter the size of the individual, these parts remain the same and, consequently, could form the best starting points (landmarks) on which to base a measure system. According to Dryden & Mardia (1998), a '*landmark*' is a point on an individual that matches within a population, while Gazzuolo (1985) has noted the need to use body landmarks as operation definitions of reference points for photogrammetric analysis.

Therefore, in order to measure as accurately as possible, different landmarks are placed on the body, pointed with small round stickers⁷³. These landmarks are used as guidelines to indicate where specific measurements should be taken. According to Chen (2011), landmark definitions vary in the apparel and anthropometry fields and the left/right angles of shoulder slopes, bust prominence, back curvature, and acromion placement are asymmetrical, while certain physical variations are correlated with one another. Therefore, future research could benefit focusing on using angle measurements to develop systems for classifying body shapes, predicting intake of bust, back, and waist darts on block patterns, and evaluating how standing posture affects apparel fit. (Chen, 2011: 301-310).

For accomplishing the measuring procedures, in this research, the *waistline* is indicated with a band⁷⁴, usually located at the narrowest circumference of the abdomen, between the lowest rib and the top of the pelvis (European Committee for Standardization, 1998), while it is very important that the subject keeps the abdomen relaxed and breaths normally.

According to Hernandez (2000), the *neck point* (NP) is located at the intersection between the base of the neck and the shoulder, the *shoulder point* (SP) is located at the utmost part of the acromion (the bony projection from the outer end of the spine of the shoulder blade, to which the collarbone is attached) and the *nape* is located at the 7th cervical vertebra (Hernandez, 2000:44).

Overall, if an individual has a significantly prominent curvature due to scoliosis, this curvature needs to be measured, as well: The highest point (peak) of the curvature is marked with the landmark C1. The landmark located vertically above C1, on the shoulder line, is called C2 (Figure G).

⁷³ The stickers can come off very easily, so that they don't cause any discomfort or pain to the individual.

⁷⁴ The band is made of cotton or wool, 15mm wide.

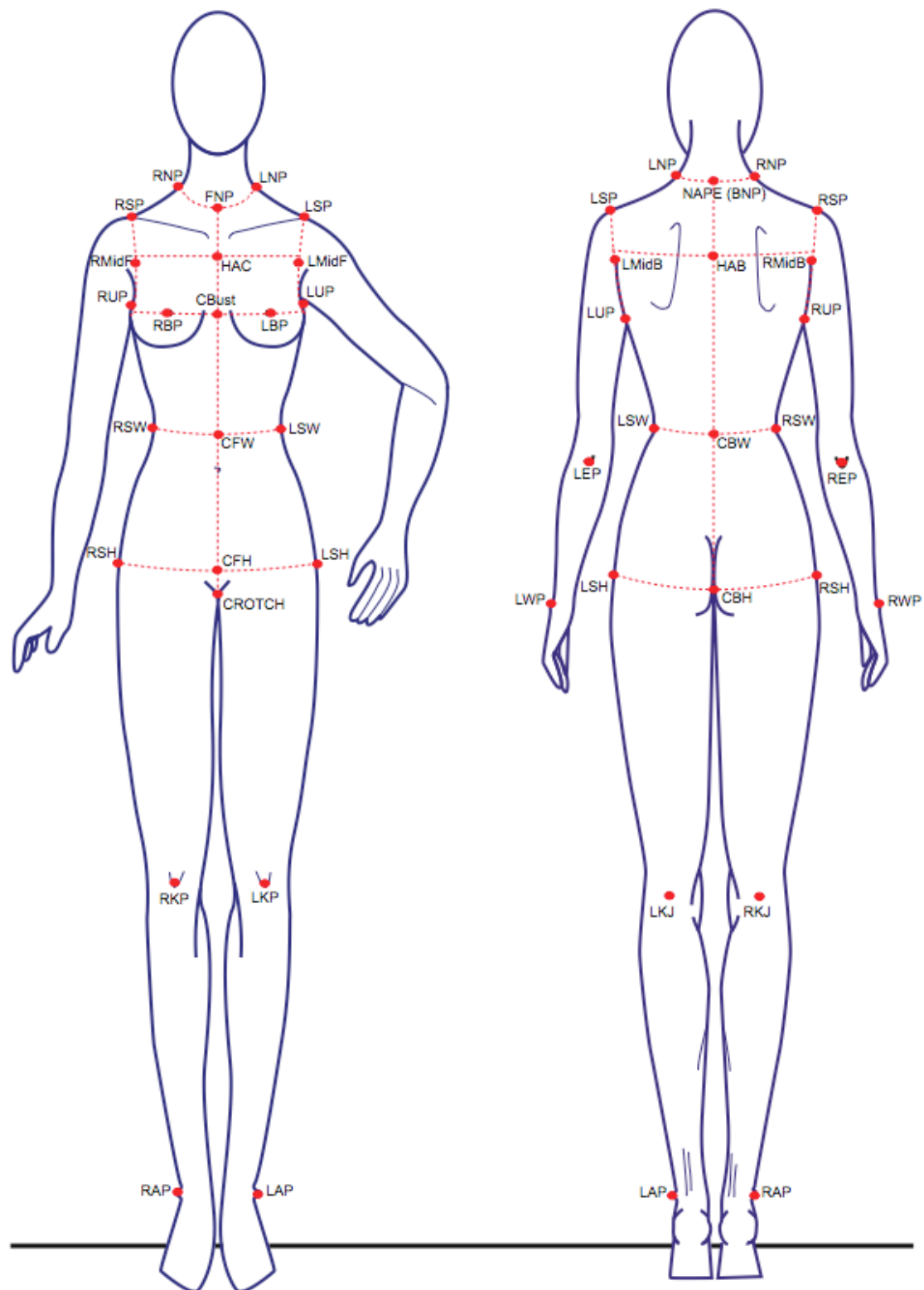


Figure A

The landmark located vertically under C1, on a horizontal line placed approximately on the waist level, is called C3 (Figure G). Thus, the location of C2 is registered by measuring the distance, on the shoulder-line, from the neck point (NP) to C2. Landmark C1 can then be easily measured with the tape measure running straight down to C3 (C2-C1-C3: measurement **54bcd**, see also Figure 6.6, Chapter 6.5.1) (Hernandez, 2000:53-54).

Landmarks enable the person who measures to find easy the correct locations when measuring, i.e. the beginning and end of a measurement (usually around a bony structure), so that they can concentrate more on all other aspects of measuring. Hence, in this study, each landmark was placed according to the anatomy of the subject: the skeleton and the muscles were significant for locating the proper placement of the landmarks (Hernandez, 2000:44):

- Shoulder tips (LSP & RSP)
- Neck-shoulder positions or breakpoints (LNP & RNP)
- Neck centres – front and back (FNP & BNP)
- Chest at centre (half across chest) (HAC)
- Bust at the centre (CBUST)
- Bust points (LBP & RBP)
- Sides at the underarm (armpit) (LUP & RUP)
- Middle of front scye (LMidF & RMidF)
- Middle of back scye (LMidB & RMidB)
- Back at the centre (half across back) (HAB)
- Elbows (LEP & REP)
- Wrist bones (LWP & RWP)

- Sides at the waist (LSW & RSW)
- Waist at the centres – front and back (CFW & CBW)
- Sides at hip level (LSH & RSH)
- Hip at the centres – front and back (CFH & CBH)
- Crotch (CROTCH)
- Knee joints (back) (LKJ & RKJ)
- Knee-caps (front) (LKP & RKP)
- Ankles (LAP & RAP)

7.2. Body Shape and Figure Analysis

Sheldon (1940) used individuals' photographs to categorize bodies, while Douty *et al.* (Douty, 1954; Douty, 1968; Douty, Moore & Hartford, 1974:499-521) tried to relate body shape to body image and attitudes towards body types, in attempts to improve fit by apparel pattern development. More specifically, Douty established the physical characteristics of college-aged females, creating scales of 5 physical features of body-build and 5 features of posture, by developing graphic somatography (Douty, 1968:21-34), a technique that projected a person's image onto a translucent screen with a grid pattern, in order to photograph front and side silhouette views and analyze the figure's angles and curves for studying the development of darts and seamlines, which would fit the bodies' shapes (Connell *et al.*, 2006:80-95). In addition, Gazzuolo (1985) studied body form variance using both anthropometric and photogrammetric analysis, understanding the need to link visual data from body form analysis to dimensional data, in order to define pattern shape. On the one hand, Biederman (1985:29-73) proposed the *Recognition-by-Components* (RBC) theory for human image understanding, whereby when an individual is being viewed, their image is segmented into volumetric

components or shapes (e.g. cylinders, cones, etc.) at points of deep concavity, where there are discontinuities in curvature.

On the other hand, Mossiman (1988) avowed that size is not related to shape, implying that all individuals who wear a specific size cannot be assumed to be the same shape, or individuals who range from small to large or short to tall within one apparel size category may have similar or different shapes (Connell *et al*, 2006:82). Overall, Connell *et al*. (2006:92) created a new female shape analysis tool, the *Body Shape Assessment Scale* (BSAS), based on Biederman's and Mossiman's theories and Douty's creation of five-step body build and posture scales, by applying theoretical constructs for analyzing shape, using body-scanning technology.

Hence, classification of female body shape is a challenging problem because there is great variability within and between human forms. The nuances of female body shapes need to be understood in a way that will reflect the knowledge of skilled pattern and fit-specialists, being applicable to pattern development that will benefit a diverse female population. Accurate identification of body shapes is a key issue to develop sizing standards for RTW clothing or made-to-measure applications. Vuruskan & Bulgun (2011) have found an objective method to classify body shapes and build up an automated process link, based on numerical evaluation parameters, whereby statistical analysis showed that there was mostly good agreement between the objective calculation method and the subjective assessments of the referees (Vuruskan & Bulgun, 2011:46-60). During the past two decades, with 3D scanning, higher processing speeds in computers and more powerful algorithms, technology offers the opportunity to attempt image and shape analysis across a large population (Costa & Cesar, 2000). Today, patterns come in standard sizes, but figures vary, resulting in differences between people's figures and

commercial patterns, while *figure variation* is a term to describe distinctions or deviations in human bodies (Chen, 2011:308).

Pattern size standards do not define beauty or fashion ideas, but are simply averages derived from people's body measurements. The sizing specifications began in the 1940s and, forming the basis of today's standards, were developed to reflect incremental changes in body measurements but not in body shapes (Connell *et al*, 2006:81). Even if having the same body measurements, fitting results for different individuals can be different based on the specifications of body shape, i.e. even if having the same, bust, waist, and hip circumferences, it is possible to have quite different body shapes for different individuals. Clearly, these circumference measurements are not the indicators of the body shape, but the ratios and relations between these values can give clues for the identification of the shape (Lele & Richstmeier, 2001; Vuruskan & Bulgun, 2011:48). The interactions between horizontal and vertical dimensions greatly affect the fit of a standard sized garment on a specific individual. While different individuals may belong to a certain size group by the key dimensions of bust and hip, the intrasize variation along key and / or other body dimensions causes a standard size garment to fit differently on each individual. For example, the variability of neck point-to-bust, bust-to-waist and waist-to-hip depths within a size group can lead to vertical mismatch between the garment bust and hip levels and the body bust and hip levels (Petrova & Ashdown, 2012:268).

Mainly, human bodies vary in relation to an ideal (average) or to one another, while, most often, vary from those averages, due to physical differences such as height, frame or bone size, propotional body areas, contours, and posture. These physical characteristics interrelate with one another, so females usually exhibit multiple figure variations (Rasband & Liechty, 2006).

Posture is bound to change slowly with age, possibly becoming more exaggerated and leading to an unbalanced figure, while it can directly influence how garments hang. Consequently, in certain cases, fitting methods may have to be modified to take posture changes into account. Poor posture is perhaps the most common figure variation, having as a result the most common problem that individuals with scoliosis have to cope with: *'the down-slanting hem'* - to which side, depending on the scoliotic curve's side: The stooping posture of their body, usually towards the opposite side of that, on which the scoliotic curve is located, leads to garment hanging on that side, while *'riding high'* on the other (scoliotic) side. In order to accommodate this, the hem of the pattern on the *'scoliotic'* side should be normally lengthened by e.g. 2-7cm (1-2.5 inches), depending on the severity of the curvature, due to spinal deformity. This would provide a hem parallel to the floor for that individual, which would be more aesthetically pleasing to the eye. Furthermore, extra comfort of movement for individuals with scoliosis could be provided, incorporating darts - hidden inside yokes, gathers or pleats, on the back upper bodice or dress blocks. On occasion, sleeves could also be designed with reduced cap height to increase comfort on bicep and improve lift, as in sportswear, while armholes (scyes) could be dropped for comfort of movement. Respectively, centre-front or centre-back seams and openings should be avoided, due to their distortion when worn on an asymmetric silhouette, whereas invisible zippers that are hidden in side-seams, could provide discretion and elegance.

The figure characteristics of an individual's silhouette are interrelated, each affecting the other. *Height, bone size or structure, proportional areas*, and the pattern of *weight distribution* are inherited traits and remain the same or constant throughout one's life. Current female body shape classifications are considered, in various categories, in pattern making and sizing terminologies. According to Rasband & Liechty (2006:24),

there are several, very typical, patterns of weight distribution, which are referred to as *body types* or *figure types*, and can be recognized or identified according to the specific areas on the body where weight tends to accumulate, regardless of height. Geometrical figures such as *triangle*, *inverted triangle*, *rectangle*, *oval* or *hourglass* shapes are some examples, as well as the *letter figures* as A, V, H, O, X, or fruits as ‘*pear*’ or ‘*apple*’, which all refer to the same figures with different codes of identification and are based on the proportions of the body silhouette mostly from the front view (Vuruskan & Bulgun, 2011:47). In addition, differentiating size chart categories with height (petite, medium, tall) or hip (slim, average, full) based groupings is another system of body figure classification for achieving better fitting (Aldrich, 1994; Joseph-Armstrong, 2000). *Figure types* are simply another guideline used to make clothing selection easier, so that an individual can look for the figure type most similar to theirs. Not every body conforms exactly to one particular type, while certain individuals have a variation or two that is atypical, e.g. due to a spinal deformity, such as scoliosis. Recognizing one’s body’s overall contours and figure type makes it easier to understand how their body relates to the average or ideal proportions, used in pattern and clothing design and manufacture. It not only appears to be an objective guide for selecting clothing styles that make visual sense and flatter a certain individual’s figure, but will also alert them to areas of their garments that may need to be altered for a better fit. Therefore, it is important to analyze a *body figure* from different points of view and to use all means available in order to make the best analysis of an individual’s body, let alone the body of an individual with scoliosis.

In attempts to produce garments that fit a range of body shapes and sizes, clothing manufacturers use a variety of methods, including manual anthropometry and 3D body scanners, in combination with CAD software systems to help the construction of customized clothing (Chen, 2001:301-310). Mass-produced garments *must* be made to

fit a variety of figures. To accomplish this, mass-produced garments may be made, either from stretchy fabrics to adapt to many different bodies, or cut loosely to accommodate different shapes.

This is not the type of garment aimed for this research - a more personalized and precise cut, a *cut that defines a female adolescent's with scoliosis unique contours*, is the primary aim. When a garment is made for a specific group of individuals and only for them - with a unique *fit* particular to their bodies alone - the fact that this garment can fit well to each individual of this group, separately, actually conceals '*flawed*' aspects of their anatomy. A garment that is expertly custom-made to fit a specific group of individuals (i.e. a group of individuals with a specific type of scoliosis, belonging to a specific body size and a specific curve size) could make their bodies, postures and proportions appear more ideal, while when this garment hangs smoothly and evenly around their bodies underneath, their bodies would give the impression of being ideally proportioned.

7.3. Compiling the Measurement Set

After having completed the experimental study on body measuring methods, I compiled a set of 54 body measurements, which were sub-divided into 154 measurements (Table 7.1, p.228), appropriate for measuring individuals' bodies with distinctive spinal curvature due to AIS. Most of the main measurements (1-54) used and described further on, are based on Niina Hernández's *Tailoring the Unique Figure* (2000), while they form a compilation of measurements used by various authors: Shoben and Ward (1987), Stanley (1991), Aldrich (1994), Joseph-Armstrong (2000), Moore, Mullet and Young (2001), Chase and Quinn (2003) Shoben and Taylor (2004) and Rasband and Liechty (2006).

The measurements were taken manually, separately or successively, both on right and left side of the subjects' bodies (75 females, aged 16-22, diagnosed with Adolescent Idiopathic Scoliosis), in order to pinpoint the difference between the two body halves, resulting in prototype basic pattern blocks, developed from this compiled set of measurements. All measurements were taken, as accurately as possible - after thorough observation of the subjects' different severity curves - by body touch using a tape measure and by following the landmarks (the procedure is described below, in Chapter 7.3.1). Overall, all these measurements were assembled in *MS Office Excel* (Subject Measurements Table – Appendix B) and imported, later, in *PolyPatternM2M* software for the construction of basic pattern blocks (based on median measurements for each scoliotic group, see Chapter 7.6:285) to fit the curves of subjects belonging to the two most populated scoliotic groups in this research (covering 63.5% of the whole sample of 75 subjects).

Measurement procedures complied with the appropriate code of ethics, in the presence of a parent or a guardian and a chaperon, and were supervised by a professional orthopaedist in a hospital setting. Access had been granted and facilitated by my advisory consultant in Greece, Prof. A. Christodoulou. Other orthopaedic specialists and other Outpatient Clinics, in large hospital settings of Thessaloniki, were also approached within the time period 2008-2010, in an attempt to obtain body measurements of as many female adolescents as possible, between 16 – 22 years of age, diagnosed with scoliosis. In the beginning of this project, the total sample goal was 150-200 adolescent girls diagnosed with AIS. Thus, every Thursday, commencing January 2008, I visited the Spine Outpatient Clinic of the 1st Orthopaedic Department at G. Papanikolaou General Hospital, while the clinic accepted patients suffering from various spinal problems. There, I started measuring 2 - 3 subjects a day, depending on the number of girls with scoliosis

who had an appointment that particular Thursday, and who happened to fit within the age-group I was examining.

The initial target was to measure 200 subjects, but this was reduced to 100, after I had measured the first 46 - owing to the fact that it was quite evident that the most populated scoliotic groups were very few, and more than 80% of the subjects fell into those few groups. After measuring the first 64 subjects, it was finally determined that 75 subjects would provide sufficient data (Subject Measurements Table – Appendix B), and that I should analyze the findings in 3 stages - for the first 25, then the first 50 and finally, for all 75 subjects – comparing the 3 sets of findings between them (Tables 7.17abc & 7.18abc, Chapter 7.5.3:276).

Prof Christodoulou, my Advisory Consultant in Greece, who is considered as an expert in Spinal Cord Surgery in Greece, was enthusiastic about my project and, commencing in September 2008, he started inviting me to his private clinic, whenever a new patient suffering from scoliosis showed up and seemed to be worth measuring. Prof Christodoulou also informed the girls about my project and encouraged them to take part in the study by completing the questionnaire and participating in the measurement-taking procedure. Prof Christodoulou's assistants, Dr E. Balabanidou, and nurse E. Tselekidou, also showed extra interest in my project and were both very helpful - they offered to call me on other weekdays, besides Thursdays, whenever a new, out-of-schedule 'scoliotic case' appeared.

7.3.1. Measuring the Body

When measuring an individual's body for the construction of a pattern, conforming to the particular individual's body measurements, it is crucial that the certain individual's body form remains the same, as it would be when wearing garments for the final wearer trial and assessment of toiles. The subject being measured should stand erect, with their feet

slightly apart, relaxed shoulders, arms and abdomen, and looking straight ahead (Rasband & Liechty, 2006:30).

Extensive body-surface measurements are not the only factors that affect apparel fit; other factors, such as body contour, relative proportion of body parts and posture – as established from the case study conclusion (Chapter 6.5.4) – are important for producing properly fitted garments. Therefore, one of the most important issues was the fact that the measurements compiled for the set used in this research, were taken while the subject maintained her normal stance and posture. This was necessary, because the body's dimensions could change noticeably as the stance of the body changed.

In the case of an adolescent girl with scoliosis, certain ethical issues have to be also considered: subject veto, state of being measured, security of data, space needs such as changing rooms, and data integrity. Another issue that appears common to both traditional and scanning approaches to body measurement, was the 'key' ethical aspect of dealing with the moderately clothed state of the person being measured. Concerns regarding the partially clothed state of the body, physical contact during measurement, and personal space issues, were all discussed with the subjects prior to exercise. After having taken each subject's consent (Appendices A - A1) and having agreed that all measurements would be taken manually, through physical contact, the procedure of measuring took place in a private examination room, in General Hospital G.

Papanikolaou, in Thessaloniki, Greece.

The whole process of measuring a subject, in this research project, lasted 45-60 minutes - in order to take 54 consistent body measurements - and varied depending on the individual's rest periods during measuring.

The reliability and validity of measurements depends on the experience of the person measuring. Practice is needed in order to measure with accuracy, and clarify that the

measurements should be taken in a way that the possibility of obtaining incorrect measurements is eliminated.

Manual measurement technologies, such as an anthropometer (for height), a balance scale (for weight) and a tape measure (for girth measurements) were employed, while two persons were involved: a trained assistant was measuring, while the researcher was registering the values. In order to measure a subject, as accurately as possible, a tape measure, a pen or pencil, a cotton cord, a ruler and a set-square were assembled, each time we visited the hospital.

In order to locate the back neck bone, the individual being measured had to bend the head forward, so that my assistant could feel the 7th cervical vertebra (nape). Then, my assistant would place the necklace or cord around the base of the person's neck. In order to locate the base of the neck in front, the individual had to shrug their shoulders so that a hollow formed at their neck base.

In order to locate the natural waistline, the assistant tied a tape or elastic string snugly around the person's waist. If the waist was hard to find (a common problem on women with extra weight or body distortion due to spinal deformity), the individual had to bend sideways. The creases that formed on both sides indicated the natural waistline.

Alternatively, the subject was asked to place the band where she believed she would like to wear the waistband of a skirt or trousers.

The person measuring (assistant) also placed a tape across the subject's bust points and shoulder blades so that the tape did not touch the body between the breast and the blades (Rasband & Liechty, 2006:91). For the girth measurements, she kept the tape snug but not tight against the person's body, while before, she had the landmarks marked with round stickers.

After identifying the landmarks on the body, each subject was measured in their underwear, wearing flat shoes with maximum heel height 1.5 inches. In case the subject

normally used shoes with different heel heights, they had to wear them while being measured. If the shoes were not worn, the posture and the body figure would change dramatically - the individual usually being more warped than if being measured with the shoes on (Hernandez, 2000:43).

Underwear should be simple - because certain underwear can change the body form (for example a '*wonderbra*') - while staying in place at all times; never ride up or slide down. It was, thus, also very important that the undergarment itself fitted properly. Their overall fit should be comfortably close to the body and smooth, without binding or constriction of any sort. Bands, straps and elastic should not cut into the body or create bulges, while straps and openings should allow for adjustment (Rasband & Liechty, 2006:33). Even the finest clothes can have unsatisfactory fit, if worn on top of undergarments that are not appropriate. Conversely, well-fitted underwear can comfortably lift, support, and control sagging body areas, eliminating an apparent figure variation, and improve the fit of clothes.

7.3.2. The Measurements

RATIONALE

The 54 measurements (sub-divided into 154 measurements for total front/total back and front left/front right, back left/back right arcs), taken from each of the 75 adolescent girls with scoliosis, were either a circumference⁷⁵ or arc (girth) or a linear measurement – including width⁷⁶ and length⁷⁷ measurements – obtained in order to '*scan*' their bodies thoroughly, from top to bottom, and to develop a body measurement table for pattern block construction (Table 7.1, below). All the measurements reflected traditional tape measure values, taken in centimetres.

⁷⁵ I.e. bust, waist, hips etc

⁷⁶ Mostly horizontal measurements, such as shoulder width and back width

The rationale was to measure both right and left body halves, while most of the times it was necessary to analyze a few different measurements, in order to create a pattern block with the best fit.

METHODOLOGY

Some of the measurements described below (Table 7.1, p.228) follow the outline of the body⁷⁸, others measure only the distance without including the outline of the body⁷⁹, and others combine the outline of the body and the distance⁸⁰. They are separated in *general*, *torso*, *arm* and *leg* measurements, while some of them are taken as *control* measurements, only used to check if the width/circumference of the garment would be large enough at that particular body area (Hernandez, 2000:46).

The use of measurements mapping various torso arcs, i.e. 'front waist widths' or 'back waist widths' versus 'waist circumference', result in a complex grade guide, in which the back of a body grades differently than the front. This type of grading in sizes, is different from most simplified grading methods used by ready-to-wear manufacturers, which usually place half of the total circumference change in the front and half in the back, thereby allowing the front and back to grade by the same increment (Moore, Mullet and Young, 2001:11). This type of grading method agrees with earlier findings by Schoefield and LaBat (2005:135-150) and their seven grading assumptions, which appeared to deviate from their anthropometric search, establishing the notion that traditional grading practices should be replaced with new grading practices based on women's body measurements.

Concerning the measurement sequence, wherever possible, measurements were taken successively. For example, the *shoulder* and *arm length* were measured without moving

⁷⁷ Mostly vertical measurements, such as sleeve length, inside leg length etc

⁷⁸ I.e. bust point, waist circumference, and thigh circumference.

⁷⁹ For example the inside leg length.

the tape measure from the *shoulder point* (SP). Also, when measuring the left/right or front/back of a circumference, it was very important to measure them successively, in order to obtain accurate values (Hernandez, 2000:45).

In addition, when measuring individuals with large disfigurements it was necessary to also take some *extra* measurements in order to register the deformity or disfigurement (Hernandez, 2000:46) and to obtain enough information about the curvature due to scoliosis, which would help to decide how much additional length or width is needed for the pattern (or the fabric, later) to fit the prominent part, depending on the location and size of the scoliotic hump.

The measurements listed below (Table 7.1), were taken from each individual with scoliosis and are simply body measurements, which when put together, would partially specify the three-dimensional (3D) shape of the body of a young woman with scoliosis. They are described and interpreted (by me, as the researcher), according to how they are generally measured, which tools are suitable to use, and how they are used in the pattern construction. In addition, they are presented in the sequence they are usually measured, numbered and shown in my own illustrations (Figures B-G), based on Helene Berglin's illustrations for Niina Hernandez's '*Tailoring the Unique Figure*' (Hernandez, 2000:44-53), modified and adapted for this research study (see List of Illustrations).

The actual measurements (Table 7.1), taken from each subject separately, were inserted as a list in *MS Office Excel* software (see Subject Measurements - Appendix B) to be used, later, for statistical analysis, and in *PolypatternM2M* software for automatic extraction of custom-made patterns, based on *median* measurements of each scoliotic group.

⁸⁰ I.e. bust circumference, nape to waist – front, outside leg length etc.

Table 7.1

1.	Height	Is the vertical measurement from the top of the head to the floor	Chase & Quinn (2003:76) Hernandez (2000:46) Shoben & Taylor (2004:9) Shoben & Ward (1987:12) Moore, Mullet & Young (2001:221)
	(Figure B & C)		
2a,b.	Dress length to knee	Is the vertical measurement from each neck point (NP) to each knee on both sides of the body	Shoben & Ward (1987:12)
	(Figure B)		

TORSO MEASUREMENTS

3a,b.	Front full bodice length (outline measurement)	Is measured at the front, from the waist, over the bust, to both left/right neck points (NP). (An average of the front and back measurements, on each side, should be calculated for the pattern design)	Chase & Quinn (2003:76) Joseph-Armstrong (2000:30) Rasband & Liechty (2006:92)
	(Figure B)		
3c,d.	Back full bodice length (outline measurement)	Is measured at the back from the waist, over the shoulder blade, to both left/right neck points (NP). (An average of the front and back measurements, on each side, should be calculated for the pattern design)	Joseph-Armstrong (2000:30) Rasband & Liechty (2006:92)
	(Figure C)		
4a,b.	Strap front	Is the outline measurement, measured diagonally from each neck point (NP) down to the 'landmark' of each armpit (left/right)	Joseph-Armstrong (2000:31)
	(Figure B)		
5a,b.	Bust point height	Is measured on the front, vertically up from the waist to the bust point on both sides of the body	Rasband & Liechty (2006:92)
	(Figure B)		
6a,b.	Bust radius	Is measured from the bust point ending under the bust mound on both sides of the body	Joseph-Armstrong (2000:30)
	(Figure D)		

7.	Centre Front Bodice	Is measured on the front, from the centre of the waist to the centre of the collarbones	Joseph-Armstrong (2000:30) Rasband & Liechty (2006:92) Moore, Mullet & Young (2001:175)
	(Figure B)		
8a,b.	Nape to bust point	Is the outline measurement, measured from the 7 th cervical vertebra (nape), around the half back neck, through the neck points (left/right) and down to the bust points (left/right)	Hernandez (2000:49) Shoben & Taylor (2004:9) Shoben & Ward (1987:12)
	(Figure D)		
9a,b.	Nape to waist front	Is measured successively to the 'nape to bust point' measurement, from the 7 th cervical vertebra (nape), around the half back neck, through the neck points, over the bust points, and straight down to the waist, on both sides of the body	Hernandez (2000:49) Shoben & Taylor (2004:9)
	(Figure D)		
10.	Chest width	Is measured across the front chest from one arm hinge (joint) to the opposite arm hinge (scye to scye)	Aldrich (1994:15) Rasband & Liechty (2006:93) Shoben & Taylor (2004:9) Moore, Mullet & Young (2001:175)
	(Figure B)		
10a,b.	Half Across chest	Is taken with a tape measure across both chest halves, imagining a vertical line straight down from centre front neck point (FNP) and measuring horizontally from this line and left/right to the left/right arm hinge	Joseph-Armstrong (2000:29)
	(Figure B)		
11.	High bust circumference	Is taken with a tape measure across the front, at armhole level, continuing around and across the back, keeping the tape at the same level	Chase & Quinn (2003:76) Rasband & Liechty (2006:93) Shoben & Taylor (2004:9)
	(Figure B & C)		

11a,b.	Front high bust width	Is measured across the front, imagining a vertical line straight down from centre front neck point (FNP), at armhole level and measuring horizontally towards both armholes (left/right)	Rasband & Liechty (2006:93)
	(Figure B)		
11c,d.	Back high bust width	Is measured successively to the 'front high bust width', imagining a vertical line straight down from centre back neck point (BNP), at armhole level, and measuring horizontally towards both armholes (left/right)	Rasband & Liechty (2006:93)
	(Figure C)		
12.	Full bust circumference	Is taken with a tape measure around the fullest part of the bust, under the arms, and vertically at the centre back while the subject is breathing normally	Aldrich (1994:15) Chase & Quinn (2003:76) Hernandez (2000:46-47) Joseph-Armstrong (2000:31) Rasband & Liechty (2006:93) Shoben & Taylor (2004:9) Shoben & Ward (1987:11) Stanley (1991:7) Moore, Mullet & Young (2001:221)
	(Figure B & C)		
12a,b.	Front full bust width	Is measured across the front, imagining a vertical line straight down from centre front neck point (FNP), at full bust level, and measuring horizontally, towards both sides (left/right)	Rasband & Liechty (2006:93) Moore, Mullet & Young (2001:175) Moore, Mullet & Young (2001:221)
	(Figure B)		
12c,d.	Back full bust width	Is measured successively to the 'front full bust width', imagining a vertical line straight down from centre back neck point (BNP), at full bust level, and measuring horizontally towards both sides (left/right)	Rasband & Liechty (2006:93) Moore, Mullet & Young (2001:175)
	(Figure C)		

13.	Bust point to bust point (bust span)	Is the distance measurement from one bust point to the other bust point	Joseph-Armstrong (2000: 29) Rasband & Liechty (2006: 94) Moore, Mullet & Young (2001:175)
	(Figure B)		
13a,b.	Half Bust Span	Is the distance measurement from the left/right bust point to the imaginary vertical line straight down from centre front neck point (FNP)	
	(Figure B)		
14.	Under bust circumference	Is taken with a tape measure across the front, under the bust and under the arms, continuing around and across the back, keeping the tape at the same level	Rasband & Liechty (2006:95) Shoben & Taylor (2004:9)
	(Figure B & C)		
14a,b.	Front under bust width	Is measured across the front, imagining a vertical line straight down from centre front neck point (FNP), at under bust level, and measuring horizontally towards both sides (left/right)	Rasband & Liechty (2006:95)
	(Figure B)		
14c,d.	Back under bust width	Is measured successively to the 'front under bust width', imagining a vertical line straight down from centre back neck point (BNP), at under bust level, and measuring horizontally towards both sides	Rasband & Liechty (2006:95)
	(Figure C)		
15.	Midriff or lower ribcage circumference	Is taken with a tape measure across the front, at the midriff level, under the arms, continuing around and across the back, keeping the tape at the same level	Rasband & Liechty (2006:95)
	(Figure B & C)		
15a,b.	Front midriff or lower ribcage width	Is measured across the front, imagining a vertical line straight down from centre front neck point (FNP), at midriff level, and measuring horizontally towards both sides	Rasband & Liechty (2006:95)
	(Figure B)		

15c,d.	Back midriff or lower ribcage width	Is measured successively to the 'front midriff width', imagining a vertical line straight down from centre back neck point (BNP), at midriff level, and measuring horizontally towards both sides	Rasband & Liechty (2006:95)
	(Figure C)		
16.	Waist circumference	Is taken with a tape measure at the narrowest circumference of the abdomen (waist level), marked with a waistband or a cord	Aldrich (1994:15) Chase & Quinn (2003:76) Hernandez (2000:47) Joseph-Armstrong (2000:31) Rasband & Liechty (2006:95) Shoben & Taylor (2004:9) Shoben & Ward (1987:11) Stanley (1991:7) Moore, Mullet & Young (2001:221)
	(Figure B & C)		
16a,b.	Front waist width	Is measured across the front, imagining a vertical line straight down from centre front neck point (FNP), at waist level, and measuring horizontally towards both sides (left/right)	Rasband & Liechty (2006:95) Moore, Mullet & Young (2001:175)
	(Figure B)		
16c,d.	Back waist width	Is measured successively to the 'front waist width', imagining a vertical line straight down from centre back neck point (BNP), at waist level, and measuring horizontally towards both sides	Rasband & Liechty (2006:95) Moore, Mullet & Young (2001:175)
	(Figure C)		
17a,b.	Side seam lengths to waist	Is measured placing a ruler $\frac{3}{4}$ to 1 inch in width (2 to 2.5cm) at the underarm, from the bottom of the ruler, down both sides of the body to the waistline	Joseph-Armstrong (2000:30) Rasband & Liechty (2006:91-92) Moore, Mullet & Young (2001:221)
	(Figure B)		
18a.	Centre Front Hip depth	Is measured on the centre front, from the bottom of the waist tape down to the landmark at the fullest hip level (CFW-CFH)	Aldrich (1994:15) Joseph-Armstrong (2000:31) Rasband & Liechty (2006:253) Shoben & Ward (1987:12)
	(Figure B & C)		

			Moore, Mullet & Young (2001:221)
18b.	Centre Back Hip depth	Is measured on the centre back, from the bottom of the waist tape down to the landmark at the fullest hip level (CBW-CBH)	Aldrich (1994:15) Joseph-Armstrong (2000: 31) Rasband & Liechty (2006: 253) Shoben & Ward (1987:12) Moore, Mullet & Young (2001:221)
	(Figure B & C)		
18c.	Left Side Hip depth	Is measured on the left side (on an imaginative side seam line), from the bottom of the waist tape down to the landmark at the fullest hip level (LSW-LSH)	Aldrich (1994:15) Joseph-Armstrong (2000: 31) Rasband & Liechty (2006: 253) Shoben & Ward (1987:12) Moore, Mullet & Young (2001:221)
	(Figure B & C)		
18d.	Right Side Hip depth	Is measured on the right side (on an imaginative side seam line), from the bottom of the waist tape down to the landmark at the fullest hip level (RSW-RSH)	Aldrich (1994:15) Joseph-Armstrong (2000: 31) Rasband & Liechty (2006: 253) Shoben & Ward (1987:12) Moore, Mullet & Young (2001:221)
	(Figure B & C)		
19.	High hip circumference	Is measured with a tape measure around the iliac crest ⁸¹ , which is positioned approximately 4 inches (10cm) below the waist ⁸²	Hernandez (2000:47-48) Joseph-Armstrong (2000: 28) Rasband & Liechty (2006: 253) Shoben & Taylor (2004:9) Shoben & Ward (1987:11) Moore, Mullet & Young (2001:221)
	(Figure B & C)		
19a,b.	Front high hip width	Is measured across the front, imagining a vertical line straight down from centre front neck point, at a 4-inches-below-the-waistline level, and measuring horizontally towards both sides (left/right)	Joseph-Armstrong (2000: 29) Rasband & Liechty (2006: 253) Moore, Mullet & Young (2001:221)
	(Figure B)		

⁸¹ (Shoben & Ward, 1987)

⁸² (Shoben & Ward, 1987; Taylor & Shoben, 1984)

19c,d.	Back high hip width	Is measured successively to the 'front high hip width' imagining a vertical line straight down from centre back neck point, at a 4-inches-below-the-waist-line level, and measuring horizontally towards both sides (l/r)	Joseph-Armstrong (2000: 29) Rasband & Liechty (2006: 253)
	(Figure C)		
20.	Hip circumference	Is taken with a tape measure at the fullest part of the hip, using the hipbone as a guide and including the buttock, about 7 to 10 inches (18 to 25.5cm) ⁸³ below the waistline, depending on the height of the subject. It is important to include a protruding stomach ⁸⁴	Aldrich (1994:15) Chase & Quinn (2003:76) Hernandez (2000:48) Joseph-Armstrong (2000: 31) Rasband & Liechty (2006: 253) Shoben & Taylor (2004:9) Shoben & Ward (1987:12) Stanley (1991:7) Moore, Mullet & Young (2001:221)
	(Figure B & C)		
20a,b.	Front hip width	Is measured across the front, imagining a vertical line straight down from centre front neck point (FNP), at full hip level, and measuring horizontally towards both sides (left/right)	Rasband & Liechty (2006: 253) Moore, Mullet & Young (2001:175)
	(Figure B)		
20c,d.	Back hip width	Is measured successively to the 'front hip width', imagining a vertical line straight down from centre back neck point (BNP), at full hip level, and measuring horizontally towards both sides	Rasband & Liechty (2006: 253) Moore, Mullet & Young (2001:175)
	(Figure C)		
21.	Neck base girth	Is taken with a tape measure fairly loosely, around the base of the neck, going through the landmark of the 7 th cervical vertebra ⁸⁵ or nape (BNP), through one neck point (LNP) - which is defined as the intersection between the base of neck girth and the	Aldrich (1994:15) Chase & Quinn (2003:76) Hernandez (2000:48) Shoben & Taylor (2004:9) Shoben & Ward (1987:12) Stanley (1991:7) Moore, Mullet & Young (2001:239)
	(Figure B & C)		

⁸³ Rasband & Liechty (2006:253)

⁸⁴ (Liechty, Pottberg, & Rasband, 1994)

⁸⁵ (European Committee for Standardization, 1998)

		shoulder line, through the centre of the collar bones (FNP), through the opposite neck point (RNP), and back to the nape	
22a,b.	Armhole or scye depth (from neck point)	Is the vertical measurement taken from each neck point (LNP & RNP), down to the imaginary armhole line (from armpit to armpit), on both sides	Aldrich (1994:15) Shoben & Taylor (2004:9) Shoben & Ward (1987:12)
	(Figure C)		
23.	Back width	Is measured across the back, between the right and left arm crease and over the shoulder blades/scapulae, about 1 inch (2.5cm) above the arm hinge ⁸⁶ (MidB) and approximately 4 inches (10.5cm) down from the nape ⁸⁷	Aldrich (1994:15) Chase & Quinn (2003:76) Hernandez (2000:49) Rasband & Liechty (2006:93) Shoben & Taylor (2004:9) Stanley (1991:7) Moore, Mullet & Young (2001:175)
	(Figure C)		
23a,b.	Half Across Back	Is measured with a tape measure across the back, imagining a vertical line straight down from the nape (BNP), at a 1-inch-above-the-arm-hinge and 4-inches-down-from-the-nape level, and measuring horizontally to the left/right arm hinge	Joseph-Armstrong (2000:29) Rasband & Liechty (2006:93) Shoben & Ward (1987:12)
	(Figure C)		
24a.	Nape to waist back (outline measurement)	Is the outline measurement from the 7 th cervical vertebra (also called 'nape') down to the waist, measuring along the projections of the back and including the outline of the shoulder blades/ scapulae ⁸⁸	Hernandez (2000:48)
	(Figure C)		
24b.	Nape to waist back (distance measurement)	Is the distance measurement, from the centre of the waist, over	Aldrich (1994:15) Chase & Quinn (2003:76) Hernandez (2000:48)

⁸⁶ (Huxley, 1996; (Liechty, Pottberg, & Rasband, 1994).

⁸⁷ (Shoben & Ward, 1987)

⁸⁸ (Telmat Industries, 1998)

	(Figure C)	the tape to the large cervical bone (7 th cervical vertebra or 'nape') at the base of the neck	Joseph-Armstrong (2000: 31) Rasband & Liechty (2006:92-93) Shoben & Taylor (2004:9) Shoben & Ward (1987:12) Stanley (1991:7) Moore, Mullet & Young (2001:175)
25ab.	Front shoulder tip width	Is measured across the front from one shoulder tip to the opposite shoulder tip, between the uttermost part of the left and right shoulder point ⁸⁹	Rasband & Liechty (2006:93)
	(Figure B)		
25cd.	Back shoulder tip width	Is measured across the back from one shoulder tip to the opposite shoulder tip, between the uttermost part of the left and right shoulder point	Rasband & Liechty (2006:93) Moore, Mullet & Young (2001:240)
	(Figure C)		
26a,b.	Shoulder length	Is the distance measurement, taken with a tape measure, between the neck point (NP) and the shoulder point (SP) ⁹⁰ , on both sides of the body (left / right)	Aldrich (1994:15) Chase & Quinn (2003:76) Hernandez (2000:49) Rasband & Liechty (2006:93) Shoben & Taylor (2004:9) Shoben & Ward (1987:12) Stanley (1991:7) Moore, Mullet & Young (2001:175)
	(Figure C)		

ARM MEASUREMENTS

27a,b.	Arm length	Also called 'overarm length', or 'sleeve length' ⁹¹ . Is measured with a tape measure, successively to the 'shoulder length' measurement, over a slightly bent elbow, approximately 120° ⁹² , and down to the wrist, just below the prominent wrist bone, on both sides of the	Aldrich (1994:15) Chase & Quinn (2003:76) Hernandez (2000:50) Rasband & Liechty (2006: 216) Shoben & Taylor (2004:9) Stanley (1991:7) Moore, Mullet & Young (2001:221)
	(Figure B)		

⁸⁹ (Corke, 1996; Huxley, 1996; Liechty, Pottberg, & Rasband, 1994)

⁹⁰ The shoulder point (SP) is located at the utmost part of the acromion (bone at end of shoulder)

⁹¹ (Kindwell, 1979; Yoon, 1994)

⁹² (Telmat Industries, 1998)

		body (left / right)	
28a,b.	Underarm length (Figure B)	Is measured, after placing a ruler $\frac{3}{4}$ to 1 inch in width (2 to 2.5cm) at the underarm, from the armpit, which is the highest point of the underarm, and down to the wrist bone, above the little finger, on both sides of the body (left / right)	Rasband & Liechty (2006: 216) Shoben & Taylor (2004:9) Shoben & Ward (1987:12) Moore, Mullet & Young (2001:221)
29a,b.	Elbow Height (Figure B)	Is measured up from the wrist bone to the back elbow joint, on both sides	Rasband & Liechty (2006: 216)
30a,b.	Elbow to underarm length (Figure B)	Is calculated by subtracting the 'elbow height' value from the total 'underarm length' value, on both sides	Rasband & Liechty (2006: 216)
31a,b.	Armhole circumference (arm joint) (Figure D)	Is measured from the front shoulder point (SP) down to the 'armhole line' ⁹³ and up again to the back shoulder point (SP), on both sides of the body	Rasband & Liechty (2006: 216) Shoben & Ward (1987:12) Stanley (1991:7)
32a,b.	Upper arm circumference ('biceps') (Figure B)	Is measured around the fullest part of the upper arm, around a relaxed biceps and triceps ⁹⁴ , on both sides of the body	Aldrich (1994:15) Chase & Quinn (2003: 76) Hernandez (2000:50) Rasband & Liechty (2006: 216) Shoben & Taylor (2004: 9) Shoben & Ward (1987:12) Stanley (1991:7) Moore, Mullet & Young (2001:175)
33a,b.	Elbow circumference (Figure B)	Is measured around the elbow, using the elbow bone as a guide, in a bent position, on both sides of the body	Rasband & Liechty (2006: 218) Shoben & Taylor (2004:9) Shoben & Ward (1987:12) Moore, Mullet & Young (2001:221)

⁹³ An imaginary horizontal line from armpit to armpit

⁹⁴ (Shoben & Ward, 1987)

34a,b.	Wrist circumference	Is measured around the wrist, over the prominent wrist bones, on both sides of the body	Aldrich (1994:15) Hernandez (2000:50) Rasband & Liechty (2006: 218) Shoben & Taylor (2004:9) Shoben & Ward (1987:12) Stanley (1991:7) Moore, Mullet & Young (2001:175)
	(Figure B)		

35a,b.	Hand	Is measured around the hand at the base of the thumb, on both sides of the body	Rasband & Liechty (2006: 218)
	(Figure B)		

CONTROL MEASUREMENTS

36a,b.	Front shoulder slope (outline measurement)	Is taken on the front, from the landmark at centre front waist (CFW), diagonally up over the bust to each shoulder point (SP), on both sides of the body (left/right)	Joseph-Armstrong (2000: 31) Rasband & Liechty (2006: 92-93) Moore, Mullet & Young (2001:221)
	(Figure B)		

36c,d.	Back shoulder slope (outline measurement)	Is taken on the back, from the landmark at centre back waist (CBW), diagonally up over the blades, to each shoulder point (SP), on both sides of the body (left/right)	Joseph-Armstrong (2000: 31) Rasband & Liechty (2006: 92-93) Moore, Mullet & Young (2001:221)
	(Figure C)		

37a,b.	Shoulder to bust (outline measurements)	Is taken on the front, successively to the 'front shoulder slope' measurement, from left/right bust point, diagonally up to left/right shoulder point (SP)	Joseph-Armstrong (2000:30) Moore, Mullet & Young (2001:175)
	(Figure B)		

38a,b.	Height of neck point – front & back	Is taken vertically, with a tape measure - the front and back measurements being obtained in succession - from the waistline at the back, through the landmark of each NP, and down to the waistline at the front, on both sides (left/right)	Hernandez (2000:52-53)
	(Figure F)		

39a,b.	Height of shoulder point – front & back	Is taken with a tape measure - the front and back measurements being obtained in succession - from the side of the waistline, through the landmark of each SP, and down again to the side of the waistline on both sides (left/right)	Hernandez (2000:53)
	(Figure F)		

40a,b.	Height of shoulder slope (distance measurement)	The distance measurement, obtained by subtracting half of the ' <i>height of shoulder point</i> ' value (51) from half of the ' <i>height of neck point</i> ' value (50), the remainder being the ' <i>height of shoulder slope</i> ' (52) ⁹⁵ , on both sides (left/right)	
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LEG MEASUREMENTS

41a.	Waist to floor – front	Is measured with a tape measure from the centre front waist (CFW), following the contour of the stomach, and then vertically down to the floor ⁹⁶	Aldrich (1994:15) Hernandez (2000:50-51) Joseph-Armstrong (2000:31) Rasband & Liechty (2006: 250)
	(Figure D)		

41b.	Waist to floor – back	Is measured with a tape measure from the centre back waist (CBW), following the contour of the buttocks, and then vertically down to the floor ⁹⁷	Aldrich (1994:15) Hernandez (2000:50-51) Joseph-Armstrong (2000: 31) Rasband & Liechty (2006: 250)
	(Figure D)		

42a,b.	Outside leg length (outline measurement)	Is measured with a tape measure from the landmarks on the sides of the waistline (LSW & RSW), following the side contours to the hip level, and vertically down to the floor ⁹⁸ , on both sides of the body	Aldrich (1994:15) Chase & Quinn (2003:76) Hernandez (2000:51) Rasband & Liechty (2006: 250) Shoben & Ward (1987: 205) Stanley (1991:7) Moore, Mullet & Young (2001:175)
	(Figure B)		

⁹⁵ [(49/2)-(50/2)=51]

⁹⁶ (Telmat Industrie, 1998)

⁹⁷ (Telmat Industrie, 1998)

⁹⁸ (Telmat Industries, 1998)

43.	Body rise – centre front (distance measurement)	Is taken with the help of a set-square and a tape measure. (The subject stands close to a wall with their feet slightly apart). The set-square is placed between the subjects' legs, right below the crotch, and at a right angle towards the wall, while the distance between the centre front waistline and the horizontal set square is measured ⁹⁹	Aldrich (1994:15) Hernandez (2000:51) Joseph-Armstrong (2000:31) Shoben & Taylor (2004:9) Moore, Mullet & Young (2001:175)
	(Figure D)		
44a,b.	Inside leg length (distance measurement)	Is measured in succession to the 'body rise – centre front', at the inseam position. From the horizontal set square the inside leg length is measured vertically down to the floor, on both sides	Chase & Quinn (2003:76) Hernandez (2000:51-52) Rasband & Liechty (2006: 250) Moore, Mullet & Young (2001:175)
	(Figure D)		
45a,b.	Body rise – side (measured seated) (outline measurement)	Is measured while the subject is sitting on a horizontal surface, from each side of the waistline, following the contour down to the widest part of the hip, and then vertically down to the horizontal surface ¹⁰⁰ , on both sides	Chase & Quinn (2003:76) Hernandez (2000:52) Shoben & Ward (1987: 205)
	(Figure E)		
46.	Crotch length	Is measured from the waist-line at centre front, through the crotch, and up to the waistline at centre back	Joseph-Armstrong (2000: 31) Rasband & Liechty (2006: 253) Moore, Mullet & Young (2001:221)
	(Figure F)		
47a,b.	Upper thigh circumference	Is measured around the fullest part of the upper leg above the knee ¹⁰¹ , approximately 2 inches (5cm) below the crotch, on both sides of the body (left / right)	Chase & Quinn (2003:76) Hernandez (2000:52) Joseph-Armstrong (2000: 31) Rasband&Liechty(2006:253) Shoben & Taylor (2004:9) Shoben & Ward (1987: 205) Stanley (1991:7)
	(Figure B)		

⁹⁹ (Hernandez, 2000)

¹⁰⁰ (Telmat Industries, 1998)

¹⁰¹ (Liechty, Pottberg, & Rasband, 1994; Telmat Industrie, 1998)

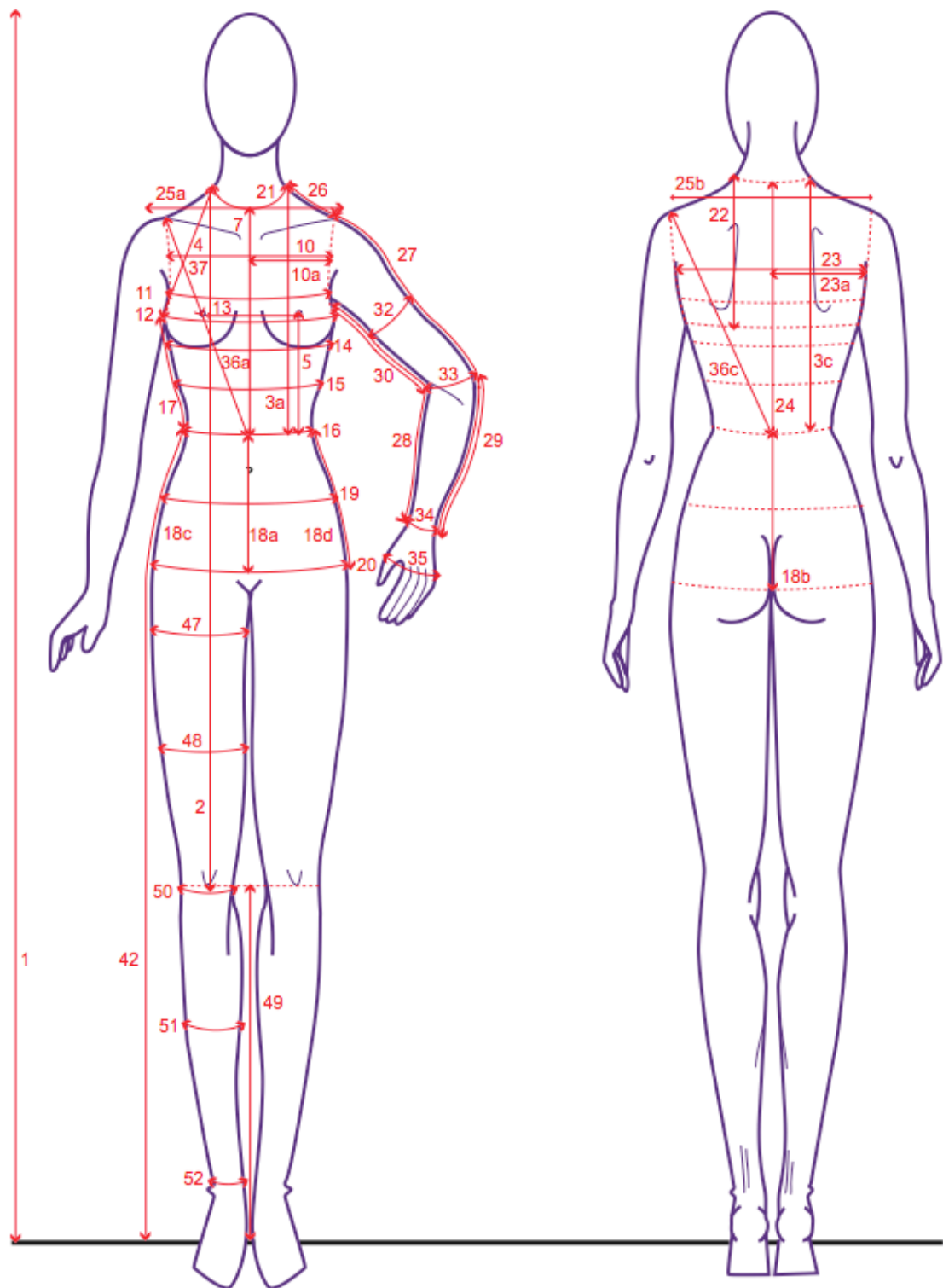
			Moore, Mullet & Young (2001:221)
48a,b.	Mid-thigh circumference	Is measured around the part of the leg located in the middle between the upper thigh and the knee, on both sides (left / right)	Joseph-Armstrong (2000:31) Moore, Mullet & Young (2001:221)
	(Figure B)		
49a,b.	Knee position	Is the distance measurement taken on the inner side of each leg, from the floor up to the kneecap, on both sides of the body (left / right)	Rasband & Liechty (2006: 250) Moore, Mullet & Young (2001:221)
	(Figure B)		
50a,b.	Knee circumference	Is measured around the fullest part of each kneecap ¹⁰² , preferably in a seated position, on both sides (left/right)	Joseph-Armstrong (2000: 31) Rasband & Liechty (2006: 254) Shoben & Taylor (2004:9) Shoben & Ward (1987: 205) Stanley (1991:7) Moore, Mullet & Young (2001:221)
	(Figure B)		
51a,b.	Calf circumference.	Is measured around the fleshy part at the back of the leg, located below the knee and above the ankle, on both sides (left / right)	Joseph-Armstrong (2000:31) Rasband & Liechty (2006: 254) Shoben & Taylor (2004:9) Shoben & Ward (1987: 205) Moore, Mullet & Young (2001:221)
	(Figure B)		
52a,b.	Ankle circumference.	Is measured around the joint that connects the bones of the leg with the highest bone of the foot, on both sides (left/right)	Aldrich (1994:15) Joseph-Armstrong (2000: 31) Shoben & Taylor (2004:9) Shoben & Ward (1987: 205) Moore, Mullet & Young (2001:221)
	(Figure B)		
53a,b.	Heel – instep circumference.	Is measured with the toes pointed, around the foot from the heel over the instep ¹⁰³ , on both sides (left / right)	Rasband & Liechty (2006: 254)
	(Figure F)		

¹⁰² A flat triangular bone located at the front of the knee. It protects the knee joint and is also called 'patella'.

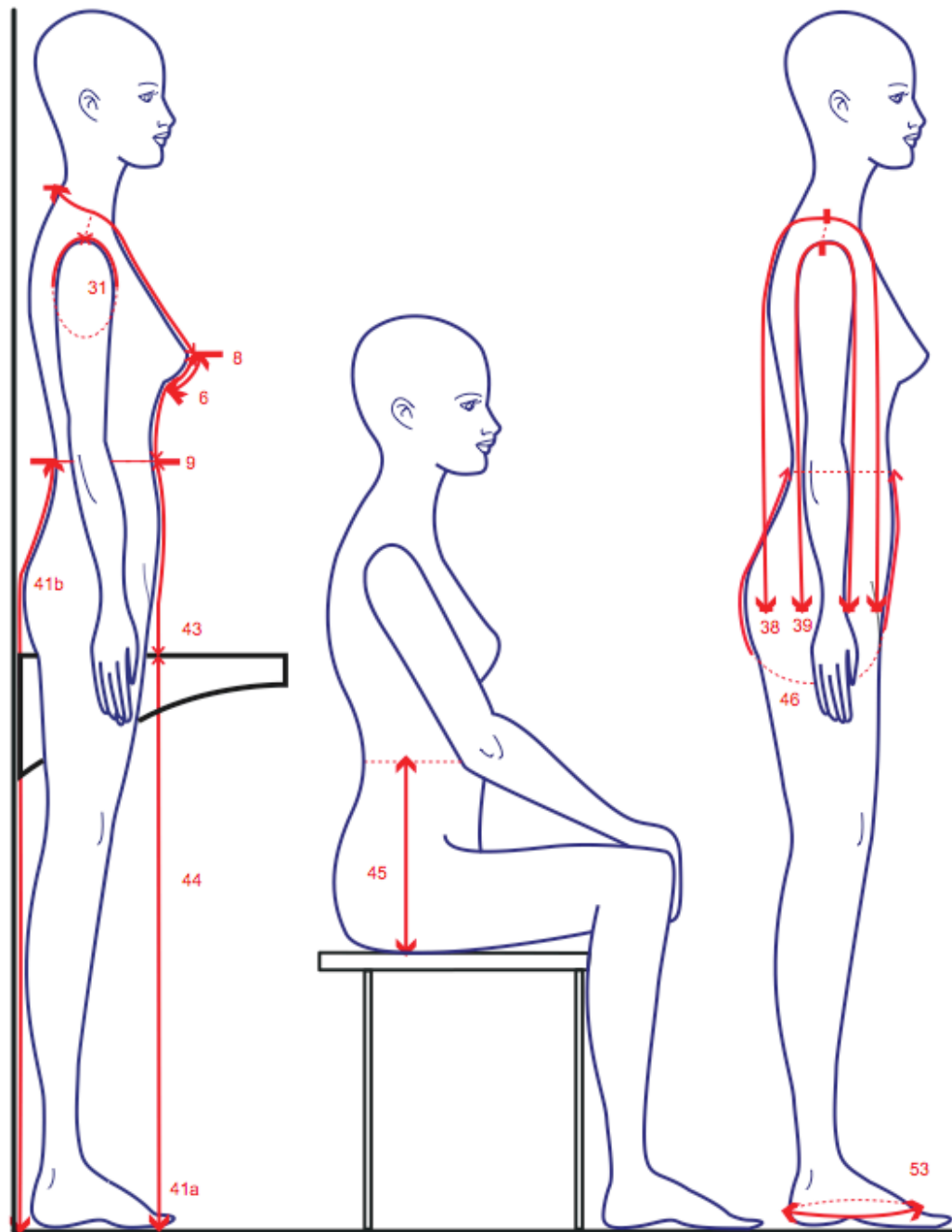
¹⁰³ The arched middle portion of the human foot between the ankle and toes, especially its upper surface

EXTRA MEASUREMENTS

54.	Location and size of the scoliotic curvature	This measurement, which consists of four different measurements, is taken in detail, depending on the size and the shape of the curvature. The basic aim is to determine its location.	Hernandez (2000:53-54)
	(Figure G)		
54a.	NP – C2.	Landmark C1 is located at the highest point (peak) of the curvature. C2 is located vertically above C1, on the imaginary shoulder line. The location of C2 is measured on the shoulder line, from the neck point (NP) to C2	Hernandez (2000:53-54)
	(Figure G)		
54b.	C2 – C1.	The outline measurement from landmark C2 down to landmark C1, located at the highest point (peak) of the scoliotic curvature	Hernandez (2000:53-54)
	(Figure G)		
54c.	C1 – C3.	The outline measurement from landmark C1 down to landmark C3, on a horizontal line, placed approximately at the waistline	Hernandez (2000:53-54)
	(Figure G)		
54d.	C2 – C3.	The outline measurement from landmark C2, located on the shoulder line, down to landmark C3, on a horizontal line, placed approximately at the waistline (is measured successively to C2-C1)	Hernandez (2000:53-54)
	(Figure G)		



Figures B & C.



Figures D, E & F.

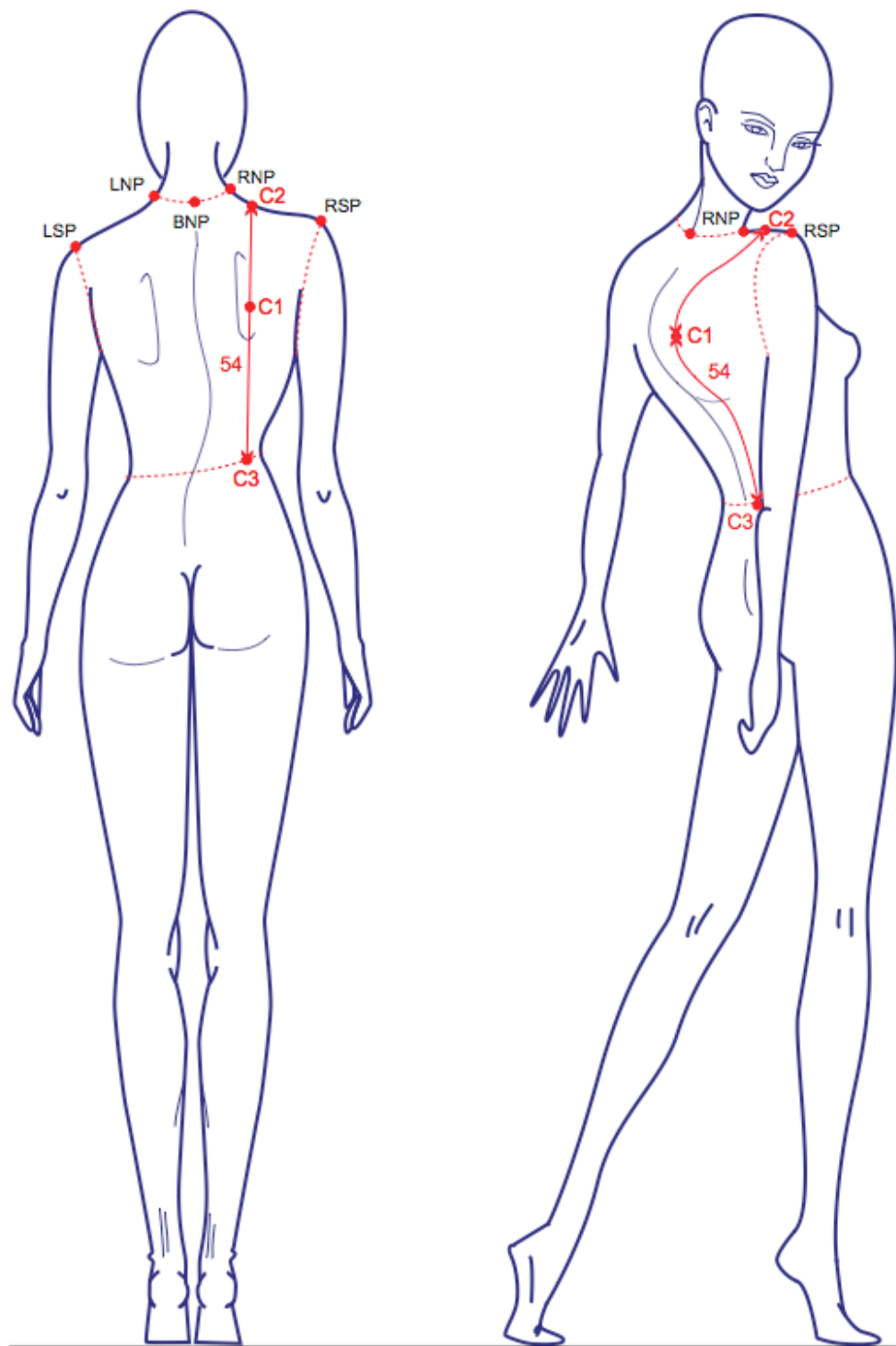


Figure G

7.4. Figure Analysis of a body affected by Scoliosis

Bust, waist and hip measurements are the main measurements for body shape identification. The ratios between these measurements show the coherency of body types (Vuruskan & Bulgun, 2011:56; Gupta & Gangadhar, 2004:464), while the value variations between right and left sides can indicate the body asymmetry due to scoliosis.

In general, certain visual assumptions could be made concerning the two most common scoliosis types (Right Thoracic and Right Thoraco-lumbar), in order to help pattern designers complete pattern quality controls (Figure 7.1.ab, below). These assumptions were further established after conducting a descriptive *summary statistics analysis* in 23 subjects (all sizes) with mild right thoraco-lumbar scoliosis (Curve Size 1) (Table 7.20a - Appendix B) and in 8 subjects (all sizes) with mild right thoracic scoliosis (Curve Size 1) (Table 7.19a - Appendix B), whereby *mean* and *median* values of their left / right *side-seam lengths-to-waist* (measur.**17a,b** – Fig. B, Chapter 7.3.2), *hip depths* (measur.**18c,d** – Fig. B, Chapter 7.3.2) and *outside leg lengths* (measur.**42a,b** – Fig. B, Chapter 7.3.2) body measurements were compared.

Left and right side seam length-to-waist values added to *left and right outside leg lengths*, respectively, were compared to define angle alignment at the *bust*, while *left and right outside leg length* values were compared to define angle alignment at the *waist*. Finally, *left and right hip depths* subtracted from *left and right outside leg length* values, respectively, were compared defining angle alignment at the *hips*.

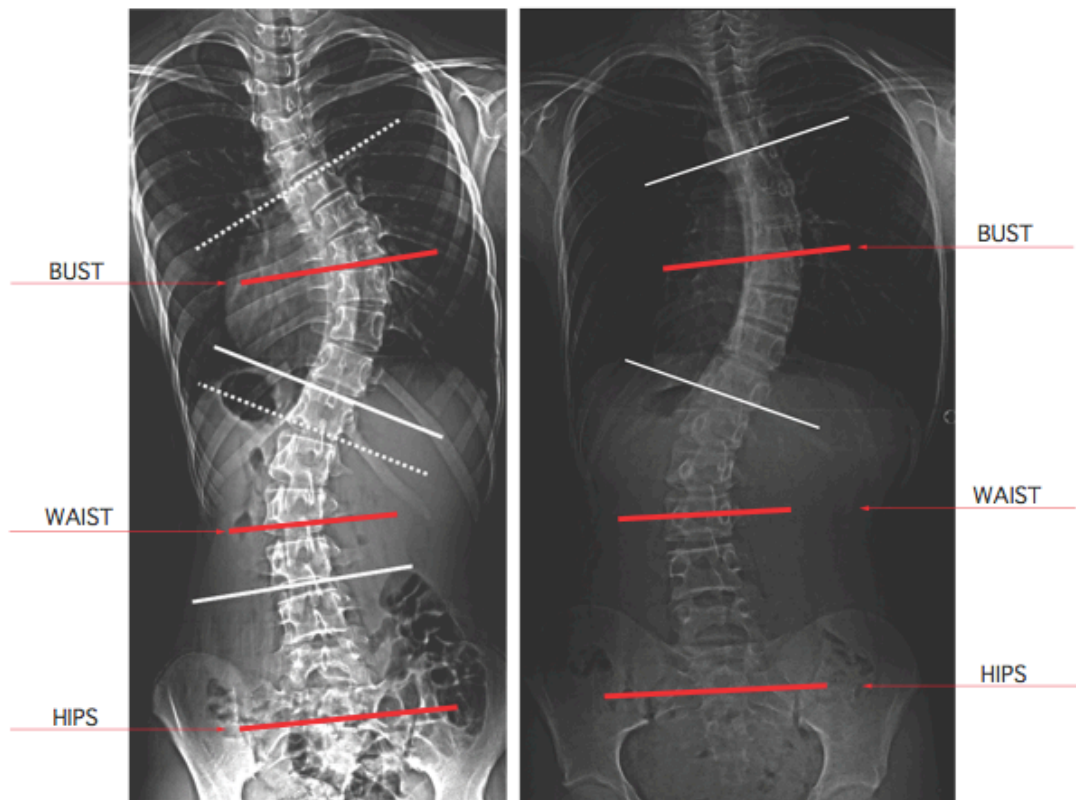


Figure 7.1(a). Neutral standing AP radiograph shows structural and non-structural curves in a 14-year-old girl with scoliosis: dextro-scoliosis (right) at the upper thoracic level (spinal segment between the dotted lines; Cobb angle, 58.8°) and levo-scoliosis (left) at the thoraco-lumbar level (spinal segment between the solid lines; Cobb angle, 32.6°).
(b). Neutral standing AP radiograph reveals during radiographic monitoring of curve progression in an 11-year-old girl with idiopathic scoliosis a rightward curvature of the thoracic spine with a Cobb angle of 49°.

Hence, it was found that:

In patients with mild (Cobb angle: 10-34°), Right, S- type, Thoraco-lumbar Scoliosis

(**C₁R_RT_SS_{TL}**: Figure 7.1.a):

- *The bust is usually shifted upwards to the right: $42a+17a < 42b+17b$*
Mean value (outside leg length left + side seam length-to-waist left): 128.39cm <
Mean value (outside leg length right + side seam length-to-waist right): 129.19),

Median value (outside leg length left + side seam length-to-waist left): 127.5cm <

Median value (outside leg length right + side seam length-to-waist right): 128.5)

- *The waist is usually shifted upwards to the right: **42a < 42b***

Mean value outside leg length left: 106.5cm < Mean value outside leg length right: 107.41cm),

Median value outside leg length left: 105.5cm < Median value outside leg length right: 107cm)

- *The hips are usually shifted upwards to the right: **42a-18c < 42b-18d***

Mean value (outside leg length left - hip depth left): 77.07cm < Mean value (outside leg length right - hip depth right): 77.89cm),

Median value (outside leg length left - hip depth left): 75.5cm < Median value (outside leg length right - hip depth right): 76.5cm)

Respectively, in patients with mild (Cobb angle: 10-34°), Right, C-type, Thoracic Scoliosis (**C₁R_RT_cS_T**: Figure 7.1.b):

- *The bust is usually shifted upwards to the right: **42a+17a < 42b+17b***

Mean value (outside leg length left + side seam length-to-waist left): 131.32cm <

Mean value (outside leg length right + side seam length-to-waist right): 131.38),

Median value (outside leg length left + side seam length-to-waist left): 130cm <

Median value (outside leg length right + side seam length-to-waist right): 130.25)

- *The waist is usually shifted upwards to the right: **42a < 42b***

Mean value outside leg length left: 109.13cm < Mean value outside leg length right: 109.69cm),

Median value outside leg length left: 108.75cm < Median value outside leg length right: 109.5cm)

- *The hips are usually shifted upwards to the right: **42a-18c < 42b-18d***

Mean value (outside leg length left - hip depth left): 83cm < Mean value (outside leg length right - hip depth right): 84.5cm),

Median value (outside leg length left - hip depth left): 82cm < Median value (outside leg length right - hip depth right): 84.25cm)

Therefore, in both 2 most common types of scoliosis ($C_1R_RT_{S_{TL}}$ and $C_1R_RT_{C_S_T}$), it is noticeable that the body is shifted upwards to the right, with the right leg being longer than the left, so that the body can retain its balance.

7.4.1. Correlations between body measurements (PCA)

A principal component analysis (PCA), including values of Cobb Angle Degrees, was conducted in order to detect the structure in the relationships between body measurements (variables), in relation to degrees of scoliosis, comparing three different sets of data: the whole scoliotic sample (Table 7.21 – Appendix B), the Right, mild Thoraco-lumbar group ($C_1R_RT_{S_{TL}}$: Table 7.22 – Appendix B) and the Right, mild Thoracic group ($C_1R_RT_{C_S_T}$: Table 7.23 – Appendix B).

The PCA illustrated a weak correlation between the *Cobb Angle degrees, the left and right horizontal offset measurements* (Figure H, pp.254) and the *corresponding vertical skew measurements* (Figure I, pp.255), while the Cobb Angle variables were positioned at 154 (last position) for the whole sample and the $C_1R_RT_{S_{TL}}$ group and at 150 (fifth before last position) for the $C_1R_RT_{C_S_T}$ group (Tables 7.21a, 7.22a & 7.23a, respectively – Appendix B).

The three different *correlation matrices* (Tables 7.21a, 7.22a & 7.23a) indicated the ranking positions for all the measurements for the three different data sets, respectively. Hence, *bust* (meas.**12**: positions 1-1-2, in each table, respectively), *waist* (meas.**16**: positions 22-27-43, respectively) and *hip* (meas.**20**: positions 5-45-15, respectively) ranked highly (highlighted with dark blue colour), while all neighbouring girth measurements presented lower ranking (highlighted with light blue colour). Moreover, certain measurements associated with scoliosis, such as *left/right nape-to-bust fronts* (meas.**8a/b**: positions 33/36-53/39-23/33, respectively), *right nape-to-waist front* (meas.**9a**: only for the **C₁R_RT_SS_{TL}** and the **C₁R_RT_CS_T** group: positions 12-39, respectively) and *left/right outside leg lengths* (meas.**42a/b**: only for the **C₁R_RT_SS_{TL}** and the **C₁R_RT_CS_T** group: positions 29/14-49/66, respectively) were also highly ranked, compared to *left/right hip depths* (meas.**18c/d**: positions 120/112-118/124-119/139, respectively) and height-related measurements defining the scoliotic curve (**54b,c,d**), which held the lowest ranking positions. At this point, it is worth noting that the width-related measurement defining the scoliotic curve (**54a**) was highly ranked only for the **C₁R_RT_CS_T** group (position 48). To conclude, *height* also ranked highly (meas.**1**: only for the **C₁R_RT_SS_{TL}** and the **C₁R_RT_CS_T** group: positions 43-67, respectively).

Thus, there is no evidence of strong correlation between the degrees of a scoliotic curve – measured with the Cobb angle – and the left / right horizontal offset or vertical skew angle of alignment at the bust, waist and hips of individuals with scoliosis, while certain variables, concerning the left and right offset horizontal measurements (measurements 12, 12d, 16, 16d and 20, 20d) and the corresponding vertical skew measurements associated with scoliosis (measurements 8ab, 9a,b and 42ab), are strongly or partially correlated to each other, in both data sets, taken from the two most populated *scoliotic*

group samples (the $C_1R_RT_S S_{TL}$ and the $C_1R_RT_C S_T$ group - Tables 7.22a & 7.23a, respectively – Appendix B).

7.4.2. Linear Regression Analysis

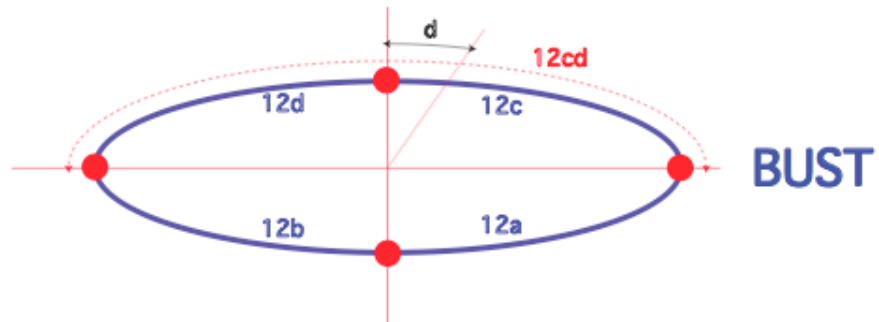
In addition, a *linear regression analysis* relating the horizontal offset at bust-waist-hips (Figure H, pp.254) and the vertical skew angle at bust-waist-hips (Figure I, pp.253) to Cobb Angle Degrees, was conducted in order to detect the structure in the relationships between variables, in relation to degrees of scoliosis, comparing *three different sets of data*: the whole scoliotic sample (Tables 7.2ab, pp.254-255), the Right Thoraco-lumbar group ($C_{1-2-3}R_RT_S S_{TL}$: Tables 7.3ab, pp.256-257) and the Right Thoracic group ($C_{1-2-3}R_RT_C S_T$: Tables 7.4ab, pp.258-259).

Regression analysis concerning the whole sample - including right and left scoliosis types (Tables 7.2ab) - and the Right Thoraco-lumbar group ($C_{1-2-3}R_RT_S S_{TL}$: Tables 7.3ab) illustrated a weak correlation between the *Cobb Angle degrees, the horizontal offset measurements and the corresponding vertical skew measurements* at bust-waist-hips. For the Right Thoracic group ($C_{1-2-3}R_RT_C S_T$: Table 7.4ab), however, regression analysis illustrated a *moderate* correlation between the *Cobb Angle degrees and the horizontal offset measurements* at the bust and hips (0.6 and 0.5, respectively) and a *weak* correlation between the *Cobb Angle degrees and the horizontal offset measurement* at the waist (0.44) (Table 7.4a).

Moreover, regression analysis suggested a *strong* correlation between the *Cobb Angle degrees and the vertical skew angle measurements* at the bust and hips (0.85 and 0.8, respectively) and a *moderate* correlation between the *Cobb Angle degrees and the vertical skew angle measurement* at the waist (0.6) (Table 7.4b).

TRANSVERSAL SECTIONS OF THE BODY AT BUST, WAIST AND HIP LEVEL

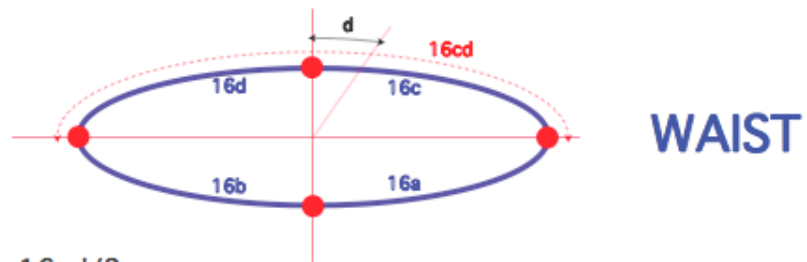
where d = horizontal offset (cm)



$$d = 12d - 12cd/2$$

Measurement 12d: Right Back full-bust circumference

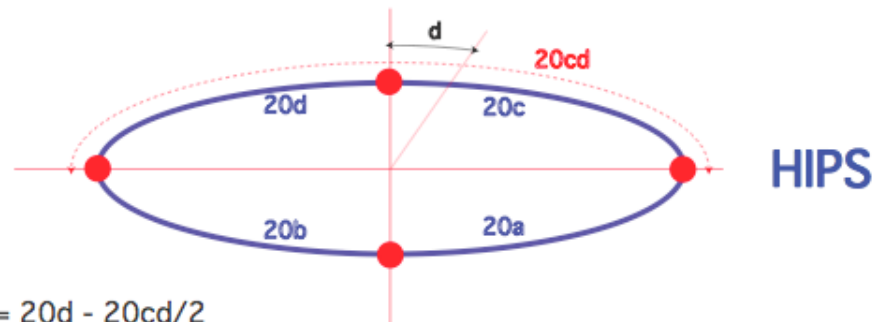
Measurement 12cd / 2: Half Total Back full-bust circumference



$$d = 16d - 16cd/2$$

Measurement 16d: Right Back waist circumference

Measurement 16cd / 2: Half Total Back waist circumference



$$d = 20d - 20cd/2$$

Measurement 20d: Right Back hip circumference

Measurement 20cd / 2: Half Total Back hip circumference

Figure H

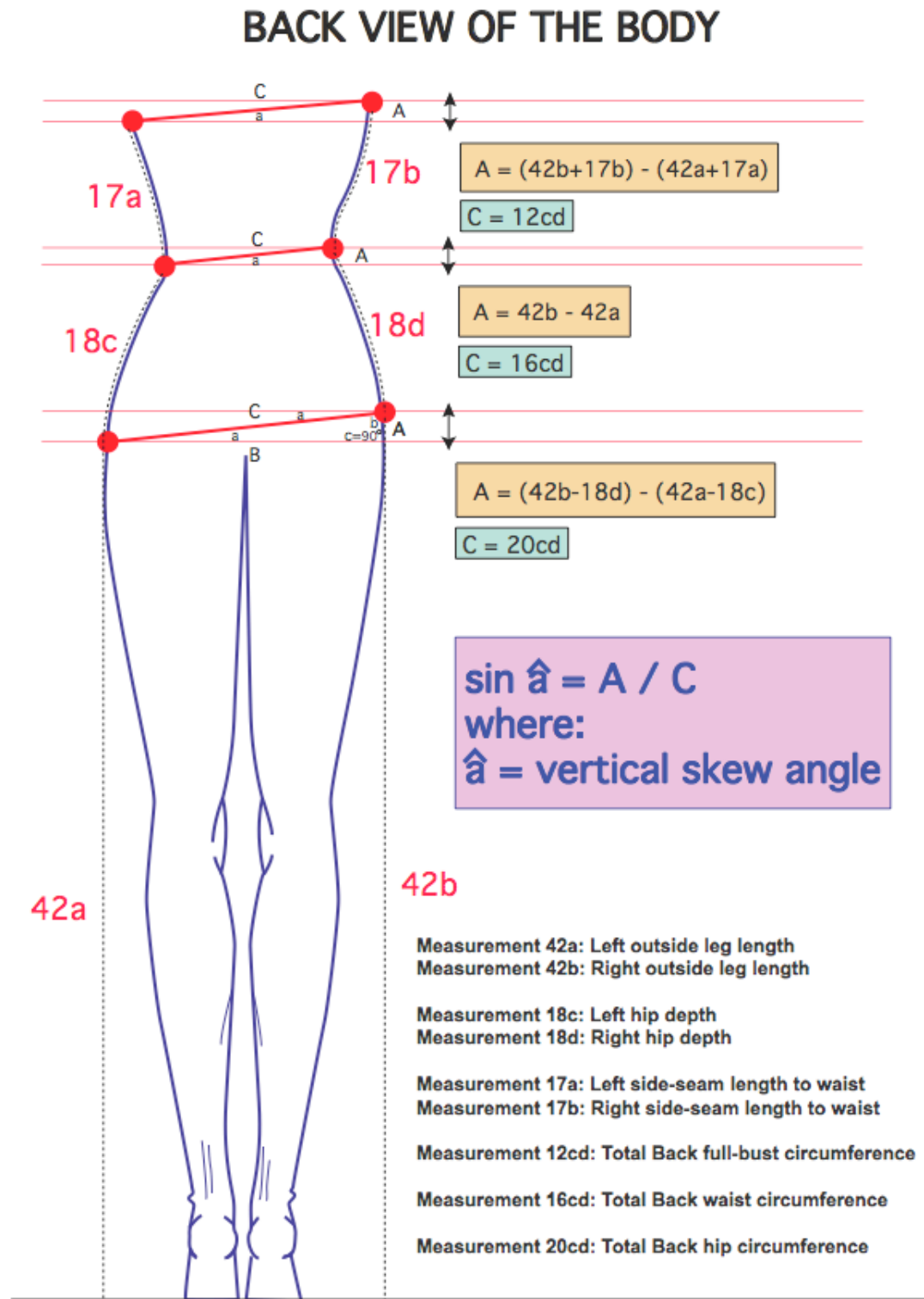


Figure I

Table 7.2a

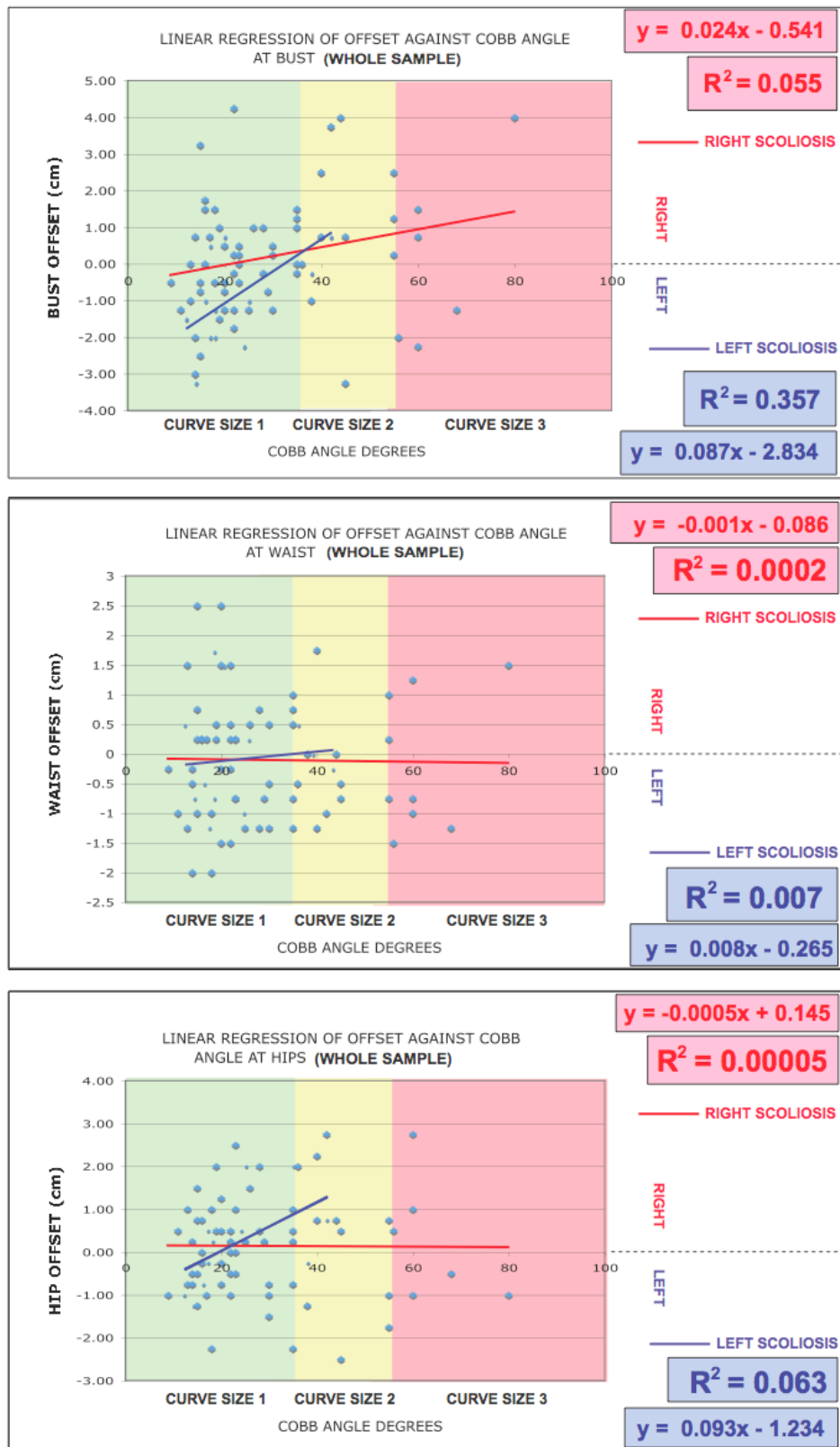


Table 7.2b

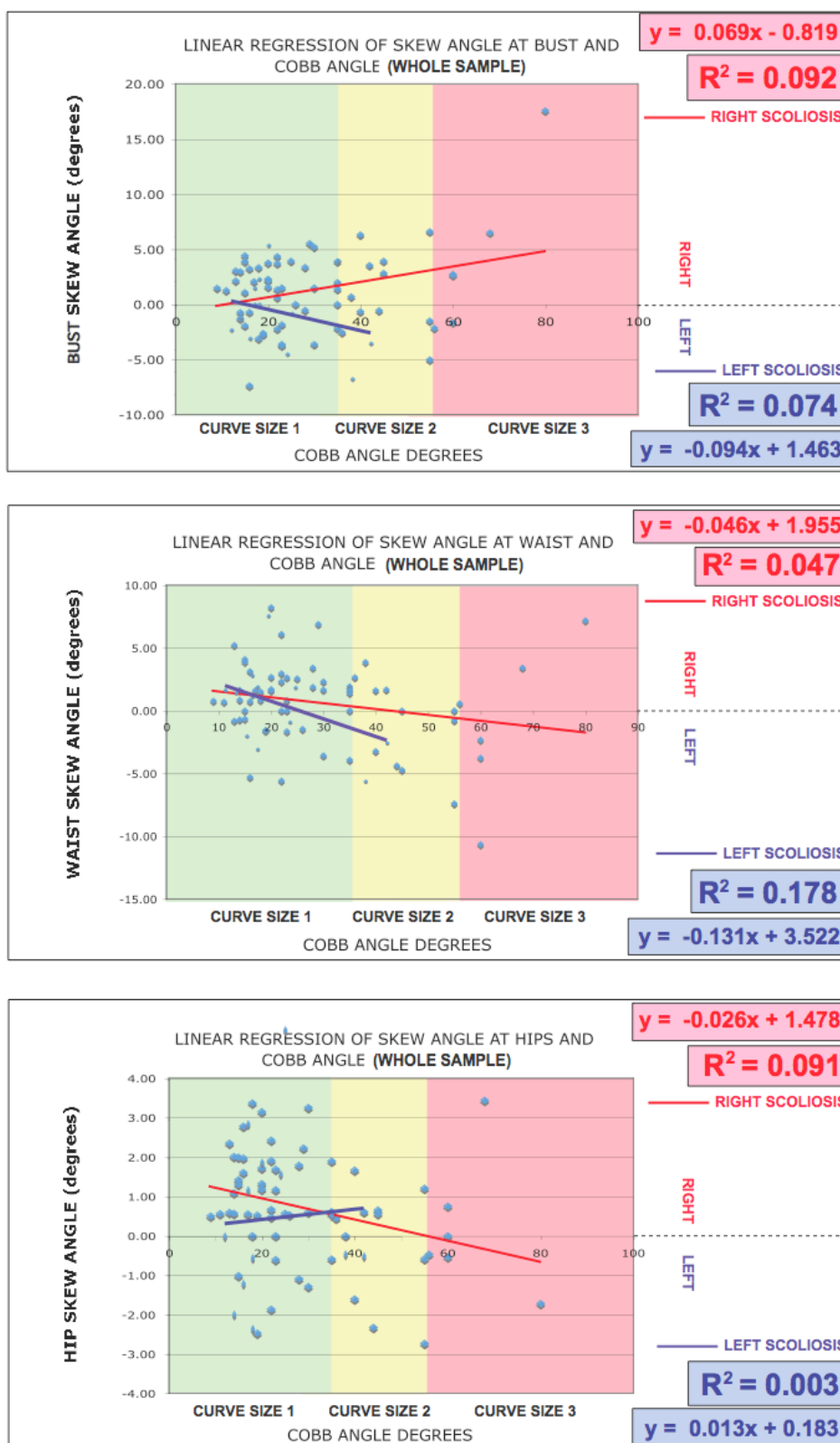


Table 7.3a

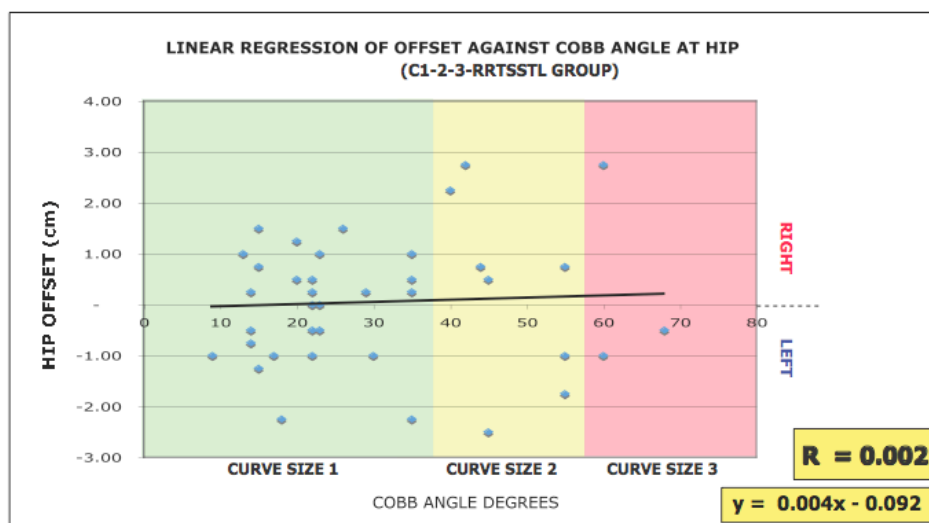
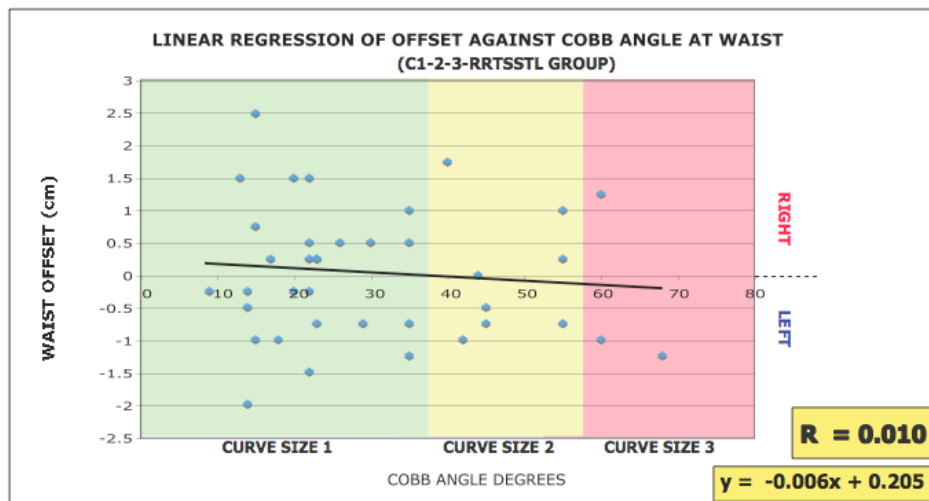
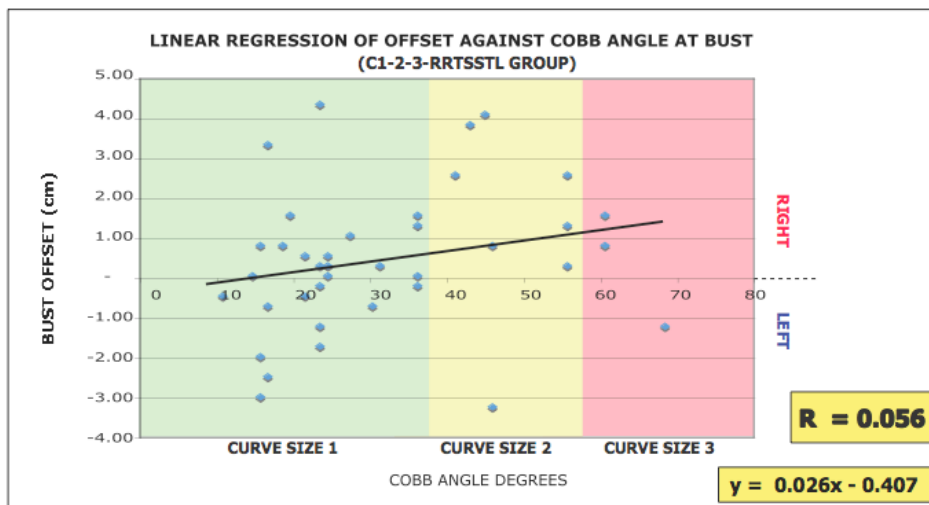


Table 7.3b

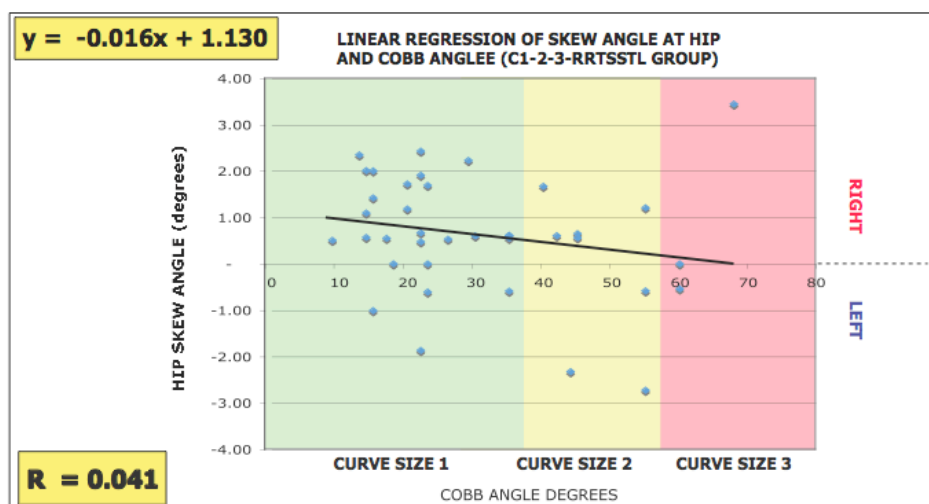
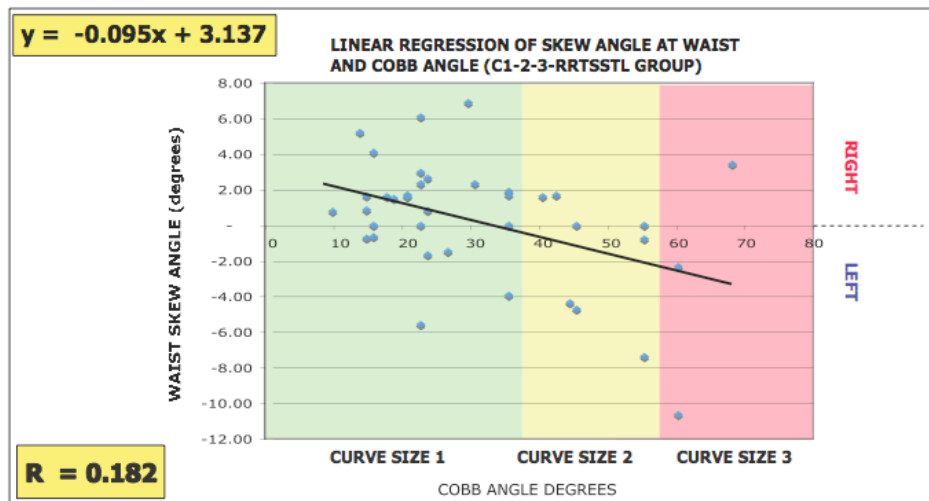
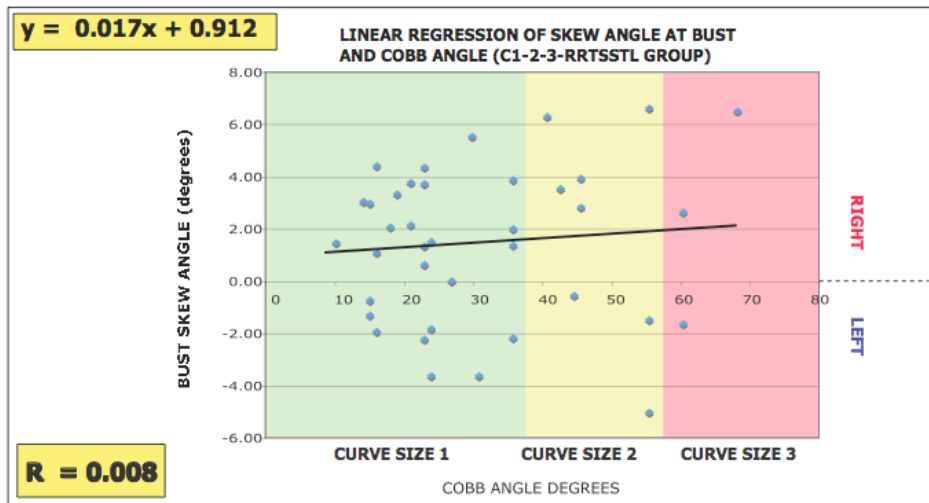


Table 7.4a

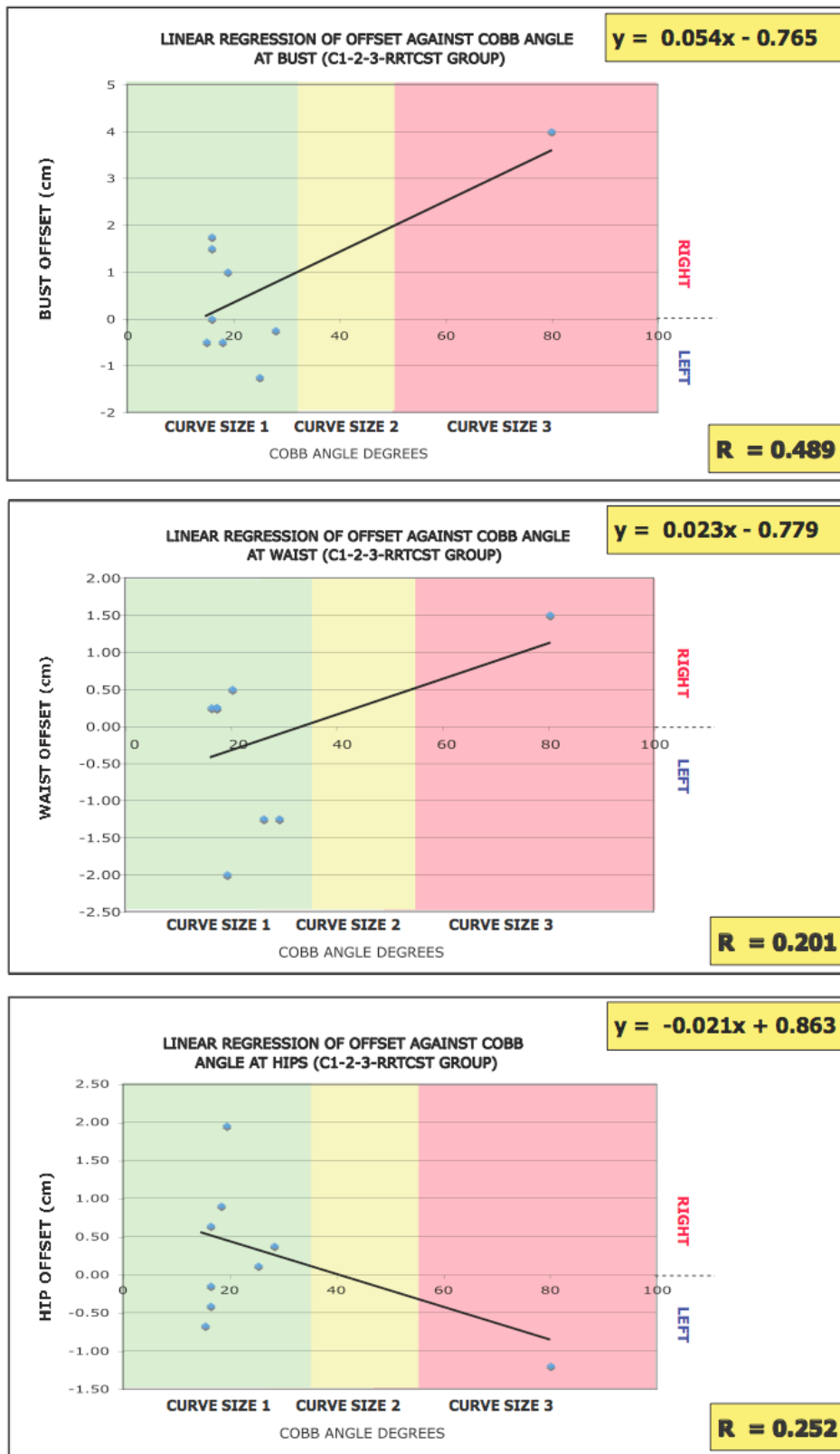
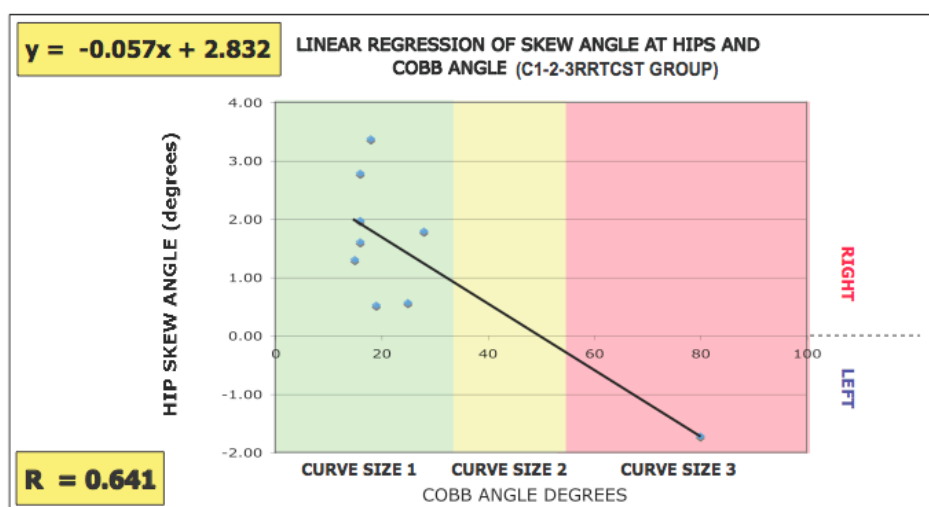
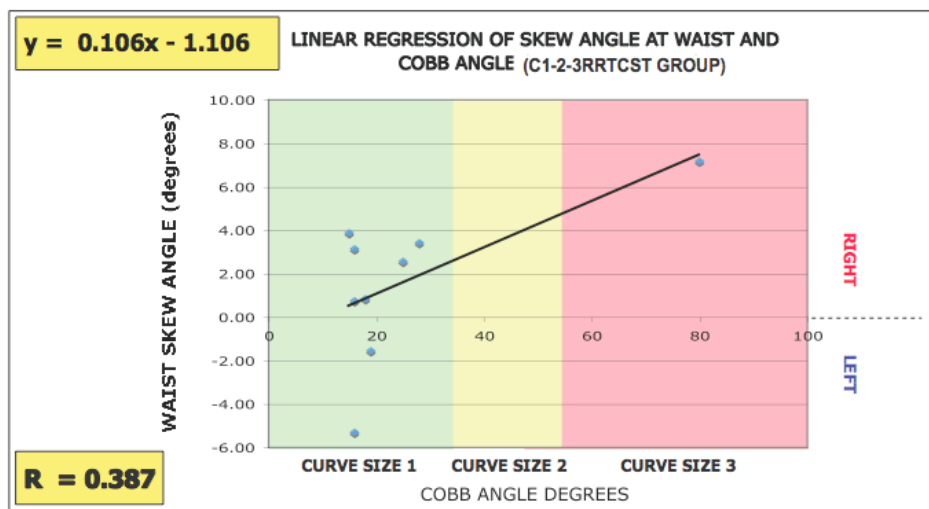
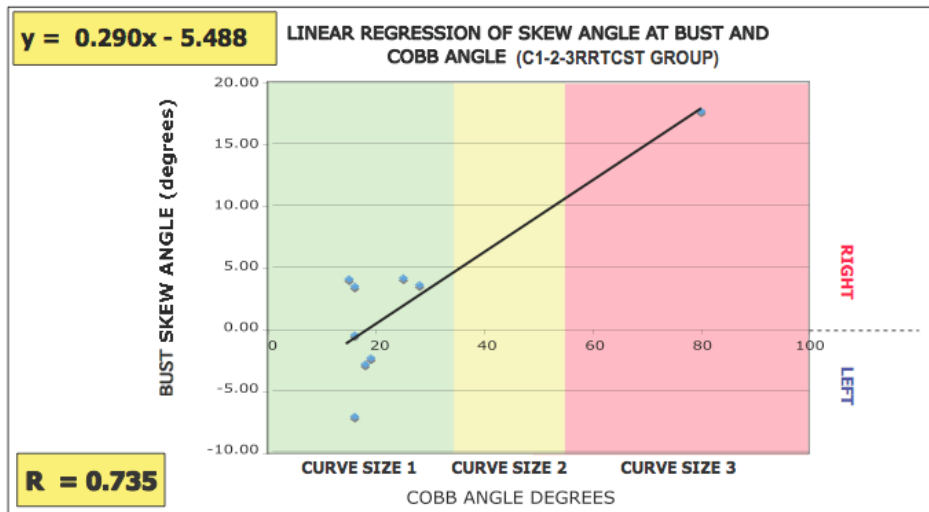


Table 7.4b



Regression analysis indicated a *strong* correlation between the *Cobb Angle degrees* and *the vertical skew angle measurements* at the bust and hips, for the Right Thoracic group, which could be justified due to the fact that Right, C-Type, Thoracic Scoliosis (**C₁R_RT_CS_T**) is a spinal deformity involving a single curve, and consequently, one dependent angle variable to the Cobb Angle.

On the contrary, regression analysis indicated a *weak* correlation between the *Cobb Angle degrees* and *the vertical skew angle measurements* at the bust and hips, for the Right, S-Type, Thoraco-lumbar Scoliosis (**C₁R_RT_SS_{TL}**), since this type of scoliosis is a spinal deformity involving a double curve, and consequently, two dependent angle variables to the Cobb Angle.

In conclusion, the above findings agree with the findings from an earlier study by Pazos *et al.* (2007:1882-1891) investigating the reliability of trunk shape measurements based on 3D surface reconstructions, which indicated that for two right thoracic scoliotic deformities with equal Cobb angle, their external asymmetries were significantly different, at least statistically. This observation strongly suggests that simple correlation between Cobb angle and one external asymmetry measure is not the best method to predict the internal deformity from the external asymmetry.

Hence, for this research project, the use of front and back arc measurements (such as '*total front waist width*' or '*total back waist width*') and separate right and left arc measurements (such as '*back left waist width*' or '*front right waist width*') versus only girth measurements ('*waist circumference*'), along with the use of certain extra measurements registering the size of the scoliotic curve (meas.**54abcd**), rendered possible the specification of the three-dimensional (3D) shape of the body of a young girl with scoliosis, pinpointing the difference between the two sagittal planes (left/right), and thus, measuring the external body asymmetry.

Therefore, along with the standard principal components (measur. 12, 16 and 20, for bust, waist and hips, respectively - Table 7.1, Chapter 7.3.2), the particular measurements (17ab, 18cd and 42ab), determining the vertical skew, should be included in the mathematical formulas obtaining the '*Aggregate Loss of Fit*', which will be calculated in the end of this research project, in order to evaluate the final pattern fit (Chapter 10.1:361).

7.5. Subject Classification in relation to their Body Size and Shape of Scoliotic Curve(s)

In the case of designing or improving a sizing system, the design criteria are to provide good fit for the greatest number of persons in the target market, to use an economically feasible number of sizes in the system and to create a system that is understandable and easy to use (e.g., size selection) for the consumer. Furthermore, body measurements from surveys need to be statistically analysed, calculating control measurements, size ranges, body proportions and size intervals. For this purpose, a comparison was made with previous tables (Subject Measurements - Appendix B) and it was concluded that the body proportion, between the time period 2008 – 2013 had, in general, remained the same, while, in certain cases, the AIS subjects' body measurements demonstrated only trivial fluctuations (in terms of body size classification), ranging between 0.5 - 3cm, concerning only their bust, waist and hip circumferences (Appendix D).

Apart from that, analysing body measurements statistically can be problematic, especially in small sample surveys. The advantages when using median measurements are that the *medians* may bring about a better fit, while the disadvantages are that the *outliers*, which may well have fitted a normal distribution curve are ignored (see Chapter 7.6).

7.5.1. The 'Greek Generic Size Chart' – A comparative review

Therefore, 75 young women, between 16-22 years of age, were measured within the time period from 2008 to 2012, at the G. Papanikolaou General Hospital of Thessaloniki (Greece), whereby 154 main body measurements were obtained (Table 7.1, Chapter 7.3.2:225). These data were used for the statistical analysis of body measurements, in order to formulate sizing charts (Tables 7.29 & 7.30, Chapter 7.6.3:297-298) and body measurement tables (see Tables 7.27 & 7.28 – Appendix B). The main control measurements of *height*, *bust*, *waist* and *hips* denoting the size of the wearer were obtained by correlation (see Subject Size Table - Appendix B), primarily classifying the subjects in a sizing system of five generic sizes (**XS** to **XL**), for five different heights (Table 7.12, pp.270), according to the Greek National Survey (Table 7.5, pp.263).

The major stage of subject classification, involved classification according to the subjects' actual body size and shape, related to their curvature degrees due to scoliosis. For this purpose and, in order to best describe a Greek adolescent girl's body dimensions, the '*Greek Generic Size Chart*' (Table 7.12, pp.270) - derived from the average measurements for hips, waist and bust, based on height and weight, for Greek women aged 20-24 years (Tables 7.5 & 7.12: Greek Institute of Bodymetrics, 2006-2007: 107-113) - was adopted, after studying and comparing body measurements for each size (Table 7.9, pp.266), between the Greek (Table 7.5, pp.263), the European (Table 7.7, pp.265) and the British (Table 7.8, pp.265) Standard Size Charts.

AVERAGE MEASUREMENTS FOR HIPS AND BUST, BASED ON HEIGHT & WEIGHT, FOR
WOMEN AGED 20-24 YEARS

Greek Institute of Bodymetrics (2006-2007: 107-113)

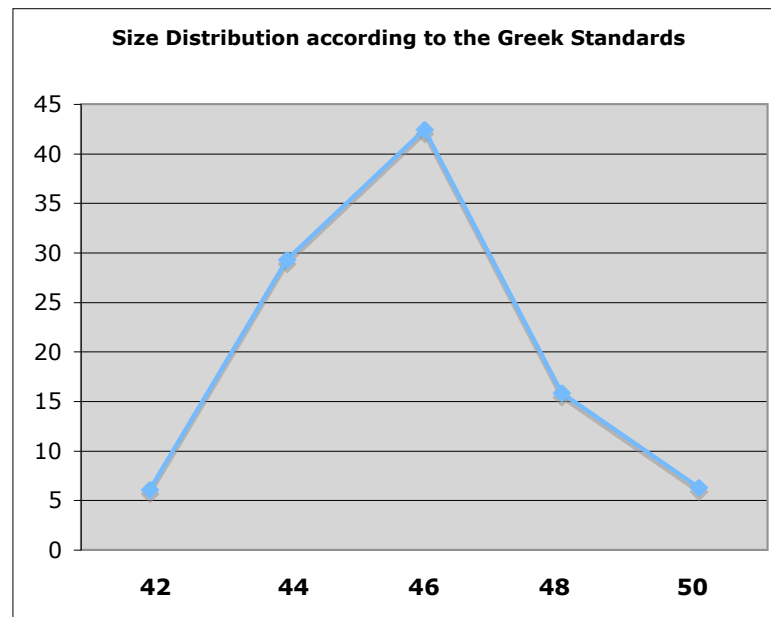
Table 7.5

SIZE	HEIGHT (cm)	WEIGHT (kg)	HIPS (cm)	WAIST (cm)	BUST (cm)
42	To 154	To 49	To 80	To 65	To 76
44	154.5 – 159.5	49.5 – 57.5	81 - 90	66 - 75	77 - 84
46	160 - 165	58 - 66	91 - 100	76 - 85	85 - 92
48	165.5 – 170.5	66.5 – 74.5	101 - 110	86 - 95	93 - 100
50	From 171	From 75	111 - 120	96 - 105	101 - 108

According to a survey conducted on 86 Greek women, by the Department of Industrial Management and Technology, University of Piraeus, in collaboration with the Greek Institute of Bodymetrics, during the time period 2006-2007, the average Greek woman aged 20-24 years was 1.63m tall and weighed 57kg, while her bust circumference was 88cm and her hip circumference 98cm (Greek Institute of Bodymetrics, 2006-2007:107-113).

Table 7.6, below, depicts the Distribution of the sample of 86 Greek women in the five different body sizes (**42, 44, 46, 48, 50**, equivalent to the generic sizes **XS, S, M, L, XL**, used in this study). The survey sample was represented by 6.1% in Size **42** (XS), 29.32% in size **44** (S), 42.44% in size **46** (M), 15.88% in size **48** (L) and 6.32% in size **50** (XL) (Greek Institute of Bodymetrics, 2006-2007:107-113).

Table 7.6



The European Union has produced a standard (EN 13402 "*Size designation of clothes*") for labeling clothes' sizes, intended to replace existing standards in the member countries. It is based on body-dimensions, the metric system (SI), data from new anthropometric studies of the European population performed in the late 1990s and existing international standards (ISO 3635). This standard consists of four parts – terms, definitions and body measurement procedure; primary and secondary dimensions; measurements and intervals; coding system - indicating the relation of the European sizes to the average dimension values of the *bust*, *waist* and *hip* circumferences (women) in relation to five different *heights* of 8cm interval between them (Table 7.7, pp.265).

Meanwhile, the United Kingdom has an existing standard for women's clothing published by British Standards Institute in 1982 (standard BS 3666:1982), traditionally indicated by numbers, for sizes from **8** to **32** quoted in centimeters, and associated with body

measurements of *bust* and *hip* girths of a *fixed height group* (164cm) of women. Table 7.8, below, depicts a set of Size Codes between sizes **8** to **18**.

AVERAGE MEASUREMENTS FOR HIPS AND BUST, BASED ON HEIGHT, FOR WOMEN AND GIRLS:

European Clothing Size Standards (EN 13402-3, Measurements and intervals;
Based on **ISO 3635, 1981)**

Table 7.7

SIZE	HEIGHT (cm)	HIPS (cm)	WAIST (cm)	BUST (cm)
36	To 156	84 - 91	61 - 67	76- 83
38	152 - 160	92 - 99	68 - 75	84 - 91
40	161 - 168	100 - 107	76 - 83	92 - 99
42	169 - 176	108 - 117	84 - 93	100 - 109
44	177 - 184	118 - 127	94 - 105	110 - 121

AVERAGE MEASUREMENTS FOR HIPS AND BUST, BASED ON HEIGHT, FOR WOMEN AND GIRLS:

British Standards Institution (BSI 3666: 1982, pp. 2-3)

Table 7.8

SIZE	HEIGHT (cm)	HIPS (cm)	BUST (cm)
8	164	82 - 86	77 - 81
10	164	86.5 – 90.5	81.5 – 85.5
12	164	91 - 95	86 - 90
14	164	95.5 – 99.5	90.5 – 94.4
16	164	100 - 104	95 - 99
18	164	105 - 109	100 - 104

A comparison of the three different sizing systems (Greek, European and British) was carried out, indicating the relation of the Greek Standards to the European and the British Standards, as well as certain differences between the three systems, and their proportional measurements (Table 7.9, below).

Table 7.9, below, shows that the Greek and European sizes lie between the British sizes, while the generic size **XL**, used in this study, is not represented by any British size. The table also indicates that both the **EU** and the **BS** sizes start from sizes **36** and **8**, respectively, which are considered as generic size **S**, used in this study, whereas the Greek sizing system begins with size **42**, which is considered as generic size **XS**, used in this study (Table 7.9, below).

A COMPARISON BETWEEN **GREEK** (Table 7.5), **EUROPEAN** (Table 7.7),
AND **BRITISH** (Table 7.8) STANDARD SIZE CHARTS

Table 7.9

GREEK SIZE	EU SIZE	BRITISH SIZE	GENERIC SIZE
42 (GREEK SIZE)	-	-	X SMALL
44 (GREEK SIZE)	36 (EU SIZE)	8-10 (BRITISH SIZE)	SMALL
46 (GREEK SIZE)	38 (EU SIZE)	12-14 (BRITISH SIZE)	MEDIUM
48 (GREEK SIZE)	40 (EU SIZE)	16-18 (BRITISH SIZE)	LARGE
50 (GREEK SIZE)	42 (EU SIZE)	-	X LARGE

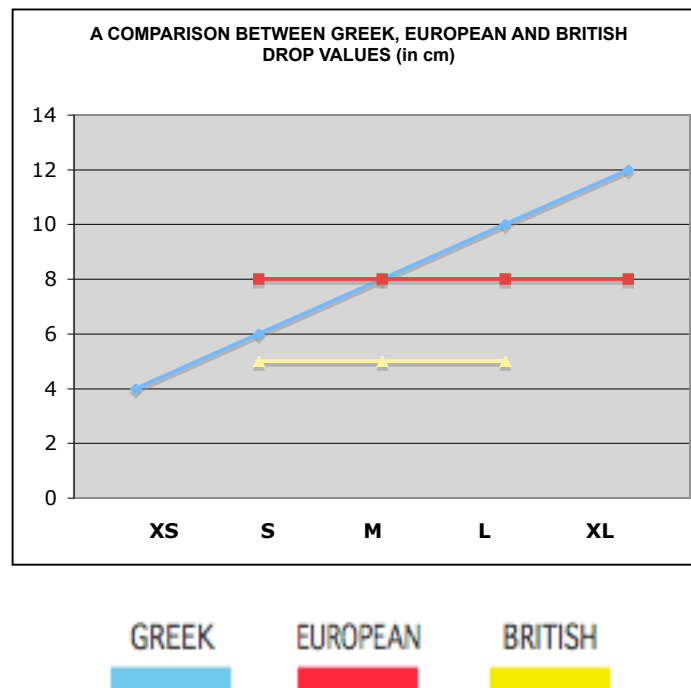
Determining the proportions of the human body is based on anatomy, which studies the shape of the human body and its proportions. Two of the most important characteristics of a sizing system are the ‘*drop*’ – the relationship (usually circumferential difference) between two *key* dimensions, i.e. *bust* and *hips* – and the ‘*intersize interval*’ or ‘*grade*’ of

the system – the value of the differences between sizes for the *key dimensions* (Petrova & Ashdown, 2012:268).

Table 7.10, below, indicates the *bust-to-hip drop value* for the three different sizing systems compared, in relation to the generic sizes used in this study. The *bust-to-hip drop value* in the Greek Sizing system ranged from 4cm for size **42** (the smallest size) to 12cm for size **50** (the largest size) (Table 7.5), while in the European Sizing system it was 8cm constant for the first four sizes (**36 - 42**), decreasing to 6cm for the largest size (**44**) (Table 7.7). In the British Sizing system the *bust-to-hip drop value* was 5cm constant for all the sizes (**8 - 18**) (Table 7.8).

A COMPARISON BETWEEN **GREEK** (Table 7.5), **EUROPEAN** (Table 7.7), AND **BRITISH** (Table 7.8) BUST-TO-HIP DROP VALUES, IN RELATION TO GENERIC SIZES

Table 7.10



It is evident from Table 7.10 that the Greek sizing system's *bust-to-hip drop* increases gradually from one size to another, reaching the highest drop (12cm) for the largest size, compared to the other two sizing systems, probably owing to the fact that Greek, and Mediterranean women in general, usually have broader hips than their Nordic counterparts.

Furthermore, observing the increase of body sizes, from the smallest to the largest size, one can notice that the values in all the three systems are different from one another. For example: according to the Greek Standards, the *hip intersize interval* is 9cm, the *waist* 7cm and the *bust* 7cm, while, according to the British Standards, both *hip* and *bust* sizes demonstrate a 4cm intersize interval from one size to another, gapping at sizes **16** and **18**. Overall, according to the European Standards, the *hip*, *waist* and *bust* sizes increase 7cm for sizes **36-40** and 9cm for sizes **42-44**.

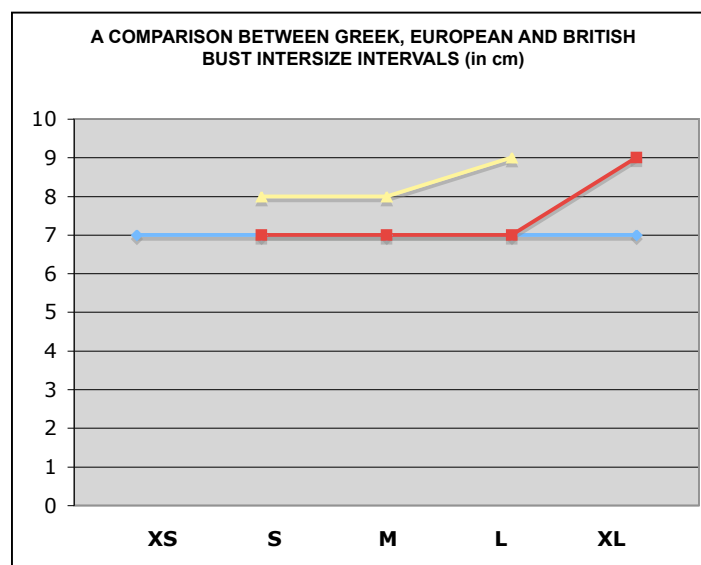
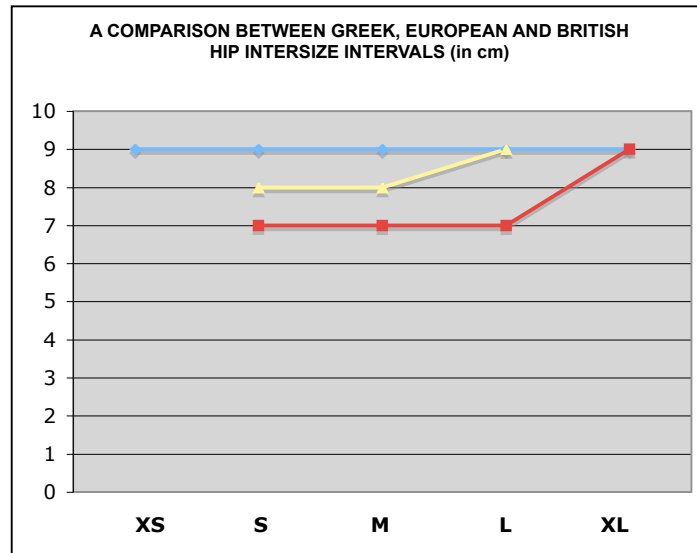
Table 7.11a-b, below, indicates the *hip* and *bust* intersize intervals for the three different sizing systems compared, in relation to the generic sizes used in this study.

On the one hand, Table 7.11a shows that the Greek *hip intersize intervals* are the highest, whereas the European are the lowest, comparing the *hip intersize intervals* in the three different sizing systems. These findings also conform to the tendency of Greek, and Mediterranean women in general, to have broader hips than their Nordic counterparts.

On the other hand, Table 7.11b shows that the Greek *bust intersize intervals* are equal to the European, up to generic size **L**, while they are lower than the European for size **XL**. Moreover, both Greek and European *bust intersize intervals* are lower than the British, up to generic size **L**, while the European and the British are equal for size **XL**.

A COMPARISON BETWEEN **GREEK** (Table 7.5), **EUROPEAN** (Table 7.7),
AND **BRITISH** (Table 7.8) INTERSIZE INTERVALS (a) FOR HIPS and (b) FOR BUST,
IN RELATION TO GENERIC SIZES

Table 7.11a-b



GREEK EUROPEAN BRITISH

■ ■ ■

On the grounds of investigations carried out in this research project, we can conclude that there do not exist unique international garment size systems. The average body dimensions have considerably changed in the last decades, all over the world, primarily owing to higher quality diet and better nutritional norms (Ujevic *et al.*, 2005:72).

Given that the most recent national sizing survey in Greece was carried out in 2006-2007 (quite recently), and that all the measurement procedures took place in a Greek hospital setting with all the participants measured, being Greek - **it was envisaged that the sizing system based on Greek Average Measurements for Hips, Waist and Bust, based on Weight and Height, for women aged 20-24 years** (Greek Institute of Bodymetrics, 2006-2007:107-113) **was the most appropriate sizing system to use for this study, as a starting point for subject classification, in relation to their body size.**

Hence, sizes **XS** to **XL** for the '*Greek Generic Size Chart*' (Table 7.12), based on Table's 7.5 average measurements of Greek women aged 20-24 years, were formed as follows:

AVERAGE MEASUREMENTS FOR HIPS AND BUST, BASED ON HEIGHT & WEIGHT, FOR
WOMEN AND GIRLS AGED 16-22 YEARS:
THE '**GREEK GENERIC SIZE CHART**'

Table 7.12

SIZE	HEIGHT (cm)	WEIGHT (kg)	HIPS (cm)	WAIST (cm)	BUST (cm)
X SMALL	To 154	To 49	To 80	To 65	To 76
SMALL	154.5 - 159.5	49.5 - 57.5	81 - 90	66 - 75	77 - 84
MEDIUM	160 - 165	58 - 66	91 - 100	76 - 85	85 - 92
LARGE	165.5 - 170.5	66.5 - 74.5	101 - 110	86 - 95	93 - 100
X LARGE	From 171	From 75	111 - 120	96 - 105	101 - 108

7.5.2. Subject Classification according to the 'Greek Generic Size Chart'

BACKGROUND

At first, the '*Greek Generic Size Chart*' (Table 7.12, pp.270), based on the Greek sizing system, consisted only of four sizes – **S** (44), **M** (46), **L** (48) and **XL** (50) – excluding the smallest size (42), as this size had no equivalent neither in the **EU**, nor in the **BS** sizing systems. Size **XS** (42) was added to Table 7.12 after measuring *Subject 16*, due to the fact that *Subject 16* hip and bust circumference measurements (Hips: 75.5cm - Bust: 69cm) were too low to fit in Greek **S** (44) hip and bust size ranges, respectively (Hips: 81-90cm - Bust: 77-84cm). After that, *Subject 33* (Hips: 80cm - Bust: 73.5cm) was also classified as **XS** (42).

RATIONALE

Using the '*Greek Generic Size Chart*' (Table 7.12, pp.270) as a starting point, after having taken each subject's body measurements separately, I primarily tried to classify each subject in one of the five different generic sizes (XS, S, M, L, XL), regardless of their type of scoliosis. Only 1 subject - *Subject 31* - was excluded from the '*Greek Generic Size Chart*', considered as '*extreme*', due to the fact that her Hip Circumference (142.5cm) was too large to fit in the **XL** size group (Hips: 111-120cm), which was the largest size group in this research project.

METHODOLOGY

According to my preliminary findings, the 74 subjects were, firstly, classified in fifteen body size groups – five for each '*curve size*' (see Chapter 2.5:38) – regardless of the type or location of their scoliotic curves, whereby Curve Size 1 Subjects represented the majority of the sample.

Table 7.13, below, depicts the Size Distribution in the five sizes, concerning the whole sample, in relation to their scoliotic Curve Size (degrees of scoliosis). Table 7.14 depicts the Size Distribution Line for the whole sample, while Table 7.15 depicts the Size Distribution Line, in relation to the three different severity curve sizes.

Tables 7.14 & 7.15 indicate a normal distribution of the scoliotic sample to the five generic body sizes, despite their scoliotic curve size.

Table 7.13

Generic Body Size	Curve Size 1	Curve Size 2	Curve Size 3	Total Percentage
EXTRA SMALL	1.35%	-	1.35%	2.7%
SMALL	21.62%	4.05%	2.7%	28.37%
MEDIUM	27.02%	10.81%	5.4%	43.24%
LARGE	10.81%	2.7%	1.35%	14.86%
EXTRA LARGE	6.75%	2.7%	1.35%	10.81%
Total Percentage	67.56%	20.27%	12.16%	100%

Table 7.14

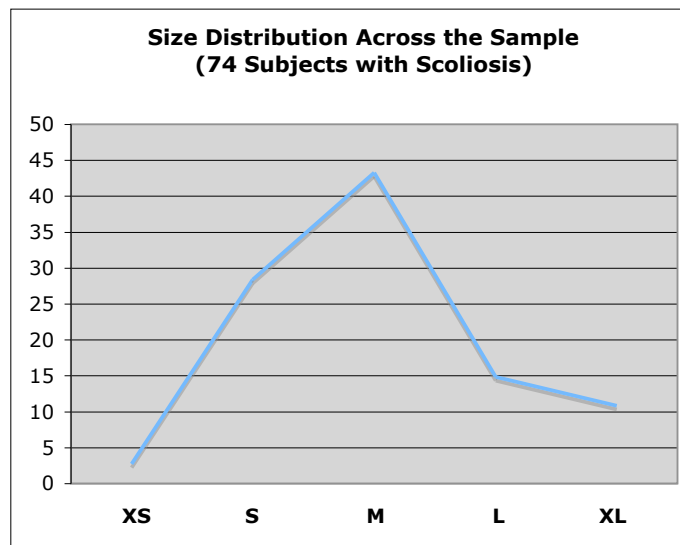
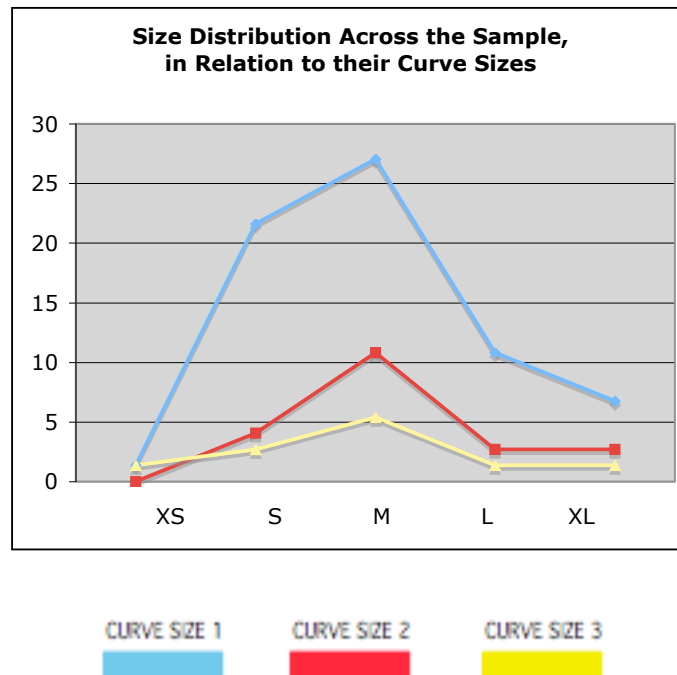


Table 7.15



At this point, it would be interesting to attempt a comparison between the distribution percentages in the five different sizes, of two samples of comparable age groups: 86 Greek women aged 20-24 years (Greek Institute of Bodymetrics, 2006-2007: 107-113) vs. 74 Greek women with Scoliosis aged 16-22 years, measured in this study (Table 7.16, pp.274). After conducting a '*Paired Two Sample for Means*' t-Test, in order to compare the size distribution values between the two samples, it was found that the value difference between the two sets of findings was statistically non-significant ($P = 0.99 > 0.05$, NS).

According to this research findings, the average Greek adolescent girl aged 16-22 years, diagnosed with some type of scoliosis of the spine, is 1.66m tall and weighs 58.82kg, her *bust* circumference is 91.25cm and her *hip* circumference 100.46cm, while the average Greek woman aged 20-24 years is 1.63m tall and weighs 57kg, her *bust* circumference is 88cm and her *hip* circumference 98cm.

Given the different age range of the two samples, the above findings point towards a normal size distribution of the scoliotic sample.

Table 7.16

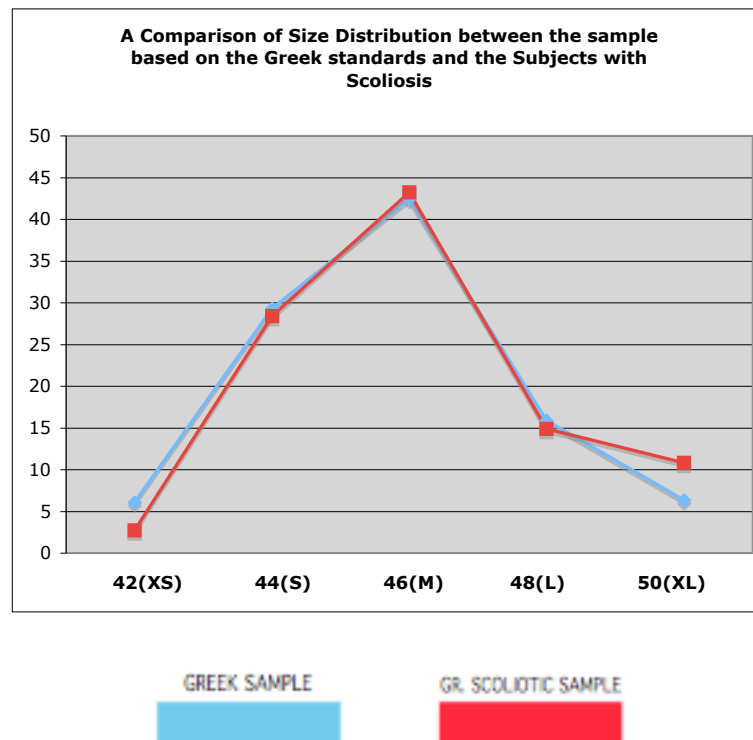


Table 7.16, above, indicates that the Size Distribution Lines of the two samples are quite similar, but not identical. It is interesting to note that there were more females classified as size **XS** (42) in the Greek National survey data (6.1% vs. 2.7%), while size **XL** (50) was much more populated in the survey accomplished for this study, regarding the scoliotic sample (10.81% vs. 6.32%). Distribution in Sizes **S** (44), **M** (46) and **L** (48) didn't show significant differences from one sample to the other.

Hence, Table 7.16 shows a tendency of girls with scoliosis to have slightly larger bodies from normal controls, although this could be due to the fact that the scoliotic sample's age range was 56.76% below 20 years – indicating that more than half of the sample

were adolescent girls, in the beginning of their maturation period, while their bodies might still experience transformations, such as volumetric increase, expanded pelvis, larger chest and more massive bones (Coillard & Rivard, 2001:1140-41).

Classifying subjects into different size groups conforming to their scoliotic curve size, proved to be a quite difficult procedure in some cases, owing to the fact that when i.e. *bust* was selected as the *key dimension* for size classification of a subject, the *hip* measurement of that particular subject didn't fit in the equivalent *hip size range*, or vice versa. For example, *Subject 12* was classified as size Curve Size 1 - **XL**, although her Hip Circumference (106cm) could fit in the Curve Size 1 - **L** hip-size range (Hips: 101-110cm), and her Bust Circumference (110.5cm) just exceeded by 2.5cm the Curve Size 1 - **XL** bust-size range (Bust: 101-108cm).

In such cases, I determined that it would be more appropriate to take into account the *weight* and *height* of the particular subject, in order to estimate in which size group they would better fit. Given that *Subject 12* weighed 75kg and measured 1.78m in height, she should be classified as size **XL** (*from 75kg and from 1.71m*).

Moreover, given that all the pattern blocks for this study were constructed with certain amounts of ease tolerance built-in (Table 8.1 – Appendix C), these extra 2.5cm of *Subject's 12* Bust-Circumference wouldn't create a problem, in terms of fitting in the dress-toile or top-toile, derived from the pattern block for size **XL**.

7.5.3. Subject Classification according to their Type of Scoliosis

Apart from the subjects' classification in three Curve Sizes (see Chapter 2.5:40), further classifications were also crucial, in relation to (Scoliosis Table, Curve Table, Subject Classification Groups - Appendix B):

- **the sagittal plane**¹⁰⁴ (Left or Right side), in which the patient's major scoliotic curve was located
- **the shape of the scoliotic curve** (C or S shape = single or compound)
- **the spinal region** [Cervical (C-shape), Cervico-Thoracic (S-shape), Thoracic (C-shape), Thoraco-Lumbar (S-shape), Lumbar (C-shape), Cervico-Thoraco-Lumbar (S-shape)], in which the scoliotic curve(s) was/were located

After gathering the measurements from 75 subjects, data were input in MS Excel (Appendix B) for analysis; 154 body measurements for each subject were generated (Subjects' Measurements - Appendix B), while the 75 subjects were primarily classified in **180 scoliotic groups** (Subject Classification Groups & Subject Groups' Average Measurements - Appendix B):

- **3 main groups** according to their spinal curve size (1, 2, 3)
- **5 sub-groups** according to their actual body size (XS, S, M, L, XL)
- **2 sub-groups** according to their curve location in relation to sagittal plane (left / right)
- **6 sub-groups** according to the curve shape and the spinal region in which the major curve was located (Cervical, Cervico-thoracic, Thoracic, Thoraco-lumbar, Lumbar, Cervico-thoraco-lumbar)

Hence:

- The first 25 subjects' classification indicated that only 14 out of the 180 groups were used, while only 6 out of these 14 groups covered 68% of all subjects (Table 7.17a). Subjects with mild scoliosis ('Curve Size 1') represented 60% ($n=15$ out of 25) of all subjects, while subjects with moderate and severe scoliosis ('Curve Size 2' and 'Curve Size 3') were represented by 24% and 16% ($n=6$ out of 25 and $n=4$ out of 25), respectively.
- The 50 subjects (actually 49 – *Subject 31* was excluded as an outlier, see p.271) measured by 22nd June 2011, were classified in only 26 of the 180 groups, while only 11 out of these 26 groups covered 69.38% of all subjects (Table 7.17b). 'Curve Size 1' subjects represented 65.3% of all subjects ($n=32$ out of 49), while 'Curve Size 2' and 'Curve Size 3' were represented by 20.4% and 14.28% ($n=10$ out of 49 and $n=7$ out of 49), respectively.
- Finally, the 75 subjects (actually 74 – *Subject 31* was excluded) measured by 12th June 2012, were classified in 36 out of 180 groups, while only 14 out of these 36 groups covered 70.27% of the whole sample (Table 7.17c)¹⁰⁵.

In conclusion, 'Curve Size 1' subjects represented 67.56% of all subjects ($n=50$ out of 74), while 'Curve Size 2' and 'Curve Size 3' were represented by 20.27% and 12.16% ($n=15$ out of 74 and $n=9$ out of 74), respectively (Table 7.17c).

¹⁰⁴ Relating to or situated on the imaginary plane that divides a human or animal body into right and left body halves

Table 7.17a

SUBJECT CLASSIFICATION IN 180 GROUPS

SUBJECT CLASSIFICATION ACCORDING TO SCOLIOSIS LOCATION	SUBJECT BODY SIZES & CURVE SIZES														
	1XS	1S	1M	1L	1XL	2XS	2S	2M	2L	2XL	3XS	3S	3M	3L	3XL
RIGHT - S - CERVICO-THORACIC											1				
RIGHT - S - THORACO-LUMBAR			3	2	1		1	4		1			2	1	
RIGHT - S - CERVICO-THORACO-LUMBAR															
RIGHT - C - CERVICAL															
RIGHT - C - THORACIC		1	4	1											
RIGHT - C - LUMBAR															
LEFT - S - CERVICO-THORACIC															
LEFT - S - THORACO-LUMBAR				1											
LEFT - S - CERVICO-THORACO-LUMBAR															
LEFT - C - CERVICAL															
LEFT - C - THORACIC		2													
LEFT - C - LUMBAR															

SAMPLE SIZE OF 25 SUBJECTS

SUBJECT CLASSIFICATION PERCENTAGE IN 180 GROUPS

SUBJECT CLASSIFICATION ACCORDING TO SCOLIOSIS LOCATION	SUBJECT BODY SIZES & CURVE SIZES														
	1XS	1S	1M	1L	1XL	2XS	2S	2M	2L	2XL	3XS	3S	3M	3L	3XL
RIGHT - S - CERVICO-THORACIC											4%				
RIGHT - S - THORACO-LUMBAR			12%	8%	4%		4%	16%		4%			8%	4%	
RIGHT - S - CERVICO-THORACO-LUMBAR															
RIGHT - C - CERVICAL															
RIGHT - C - THORACIC		4%	16%	4%											
RIGHT - C - LUMBAR															
LEFT - S - CERVICO-THORACIC															
LEFT - S - THORACO-LUMBAR				4%											
LEFT - S - CERVICO-THORACO-LUMBAR															
LEFT - C - CERVICAL															
LEFT - C - THORACIC		8%													
LEFT - C - LUMBAR															

SAMPLE SIZE OF 25 SUBJECTS

 UP TO 5%
 FROM 5% TO 10%
 FROM 10% TO 20%

¹⁰⁵ The highlighted groups in tables 7.17abc represent the groups evaluated after the wearer trial.

Table 7.17b

SUBJECT CLASSIFICATION IN 180 GROUPS

SUBJECT CLASSIFICATION ACCORDING TO SCOLIOSIS LOCATION	SUBJECT BODY SIZES & CURVE SIZES														
	1XS	1S	1M	1L	1XL	2XS	2S	2M	2L	2XL	3XS	3S	3M	3L	3XL
RIGHT - S - CERVICO-THORACIC		2		1				1	1		1				1
RIGHT - S - THORACO-LUMBAR		2	6	4	2		1	5		1		2	2	1	
RIGHT - S - CERVICO-THORACO-LUMBAR															
RIGHT - C - CERVICAL															
RIGHT - C - THORACIC		2	4	1											
RIGHT - C - LUMBAR	1														
LEFT - S - CERVICO-THORACIC					1										
LEFT - S - THORACO-LUMBAR				1	1				1						
LEFT - S - CERVICO-THORACO-LUMBAR															
LEFT - C - CERVICAL															
LEFT - C - THORACIC		3	1												
LEFT - C - LUMBAR															

SAMPLE SIZE OF 49 SUBJECTS

SUBJECT CLASSIFICATION PERCENTAGE IN 180 GROUPS

SUBJECT CLASSIFICATION ACCORDING TO SCOLIOSIS LOCATION	SUBJECT BODY SIZES & CURVE SIZES														
	1XS	1S	1M	1L	1XL	2XS	2S	2M	2L	2XL	3XS	3S	3M	3L	3XL
RIGHT - S - CERVICO-THORACIC		4.08%		2.04%				2.04%	2.04%		2.04%				2.04%
RIGHT - S - THORACO-LUMBAR		4.08%	12.24%	8.16%	4.08%		2.04%	10.2%		2.04%		4.08%	4.08%	2.04%	
RIGHT - S - CERVICO-THORACO-LUMBAR															
RIGHT - C - CERVICAL															
RIGHT - C - THORACIC		4.08%	8.16%	2.04%											
RIGHT - C - LUMBAR	2.04%														
LEFT - S - CERVICO-THORACIC					2.04%										
LEFT - S - THORACO-LUMBAR				2.04%	2.04%				2.04%						
LEFT - S - CERVICO-THORACO-LUMBAR															
LEFT - C - CERVICAL															
LEFT - C - THORACIC		6.12%	2.04%												
LEFT - C - LUMBAR															

SAMPLE SIZE OF 49 SUBJECTS

 UP TO 5%
 FROM 5% TO 10%
 FROM 10% TO 20%

Table 7.17c

SUBJECT CLASSIFICATION IN 180 GROUPS




SUBJECT CLASSIFICATION ACCORDING TO SCOLIOSIS LOCATION	SUBJECT BODY SIZES & CURVE SIZES														
	1XS	1S	1M	1L	1XL	2XS	2S	2M	2L	2XL	3XS	3S	3M	3L	3XL
RIGHT - S - CERVICO-THORACIC		2	2	1				1	1		1				1
RIGHT - S - THORACO-LUMBAR		5	11	5	2		3	5		1		2	3	1	
RIGHT - S - CERVICO-THORACO-LUMBAR		2						1		1					
RIGHT - C - CERVICAL															
RIGHT - C - THORACIC		3	4	1									1		
RIGHT - C - LUMBAR	1														
LEFT - S - CERVICO-THORACIC		1	1		1										
LEFT - S - THORACO-LUMBAR			1	1	1			1	1						
LEFT - S - CERVICO-THORACO-LUMBAR															
LEFT - C - CERVICAL															
LEFT - C - THORACIC		3	1		1										
LEFT - C - LUMBAR															

SAMPLE SIZE OF 74 SUBJECTS

SUBJECT CLASSIFICATION PERCENTAGE IN 180 GROUPS

SUBJECT CLASSIFICATION ACCORDING TO SCOLIOSIS LOCATION	SUBJECT BODY SIZES & CURVE SIZES														
	1XS	1S	1M	1L	1XL	2XS	2S	2M	2L	2XL	3XS	3S	3M	3L	3XL
RIGHT - S - CERVICO-THORACIC		2.70%	2.70%	1.35%				1.35%	1.35%		1.35%				1.35%
RIGHT - S - THORACO-LUMBAR		6.75%	14.86%	6.75%	2.70%		4.05%	6.75%		1.35%		2.70%	4.05%	1.35%	
RIGHT - S - CERVICO-THORACO-LUMBAR		2.70%						1.35%		1.35%					
RIGHT - C - CERVICAL															
RIGHT - C - THORACIC		4.05%	5.40%	1.35%									1.35%		
RIGHT - C - LUMBAR	1.35%														
LEFT - S - CERVICO-THORACIC		1.35%	1.35%		1.35%										
LEFT - S - THORACO-LUMBAR			1.35%	1.35%	1.35%			1.35%	1.35%						
LEFT - S - CERVICO-THORACO-LUMBAR															
LEFT - C - CERVICAL															
LEFT - C - THORACIC		4.05%	1.35%		1.35%										
LEFT - C - LUMBAR															

SAMPLE SIZE OF 74 SUBJECTS

 UP TO 5%
 FROM 5% TO 10%
 FROM 10% TO 20%

It is worth mentioning that more than half of the sample (51.35%: $n = 38$) belonged to the Right Thoraco-lumbar group (including curve sizes 1,2,3) ($\mathbf{C_{1-2-3}R_R T_S S_{TL}}$), while another 12.16% ($n = 9$) belonged to the Right Thoracic group (including curve sizes 1,2,3) ($\mathbf{C_{1-2-3}R_R T_C S_T}$). Covering together 63.5% of the whole sample, these two groups were found to be the two most populated scoliotic groups in this study.

Moreover, 58.10% ($n = 43$) belonged to the Right & Left Thoraco-lumbar groups (including curve sizes 1,2,3) ($\mathbf{C_{1-2-3}R_{R-L} T_S S_{TL}}$), while 18.91% ($n = 14$) belonged to the Right & Left Thoracic groups (including curve sizes 1,2,3) ($\mathbf{C_{1-2-3}R_{R-L} T_C S_T}$), covering together **77.02%** of the whole sample.

Overall, based on medical knowledge, left and right scoliosis types have been found to have the same clinical symptoms, despite the deformity's location side. Hence, **the above 180 classification groups could be reduced to 90**, if left and right scoliosis types were classified in the same group, differentiated only by the scoliotic curve's shape and size¹⁰⁶.

In this case:

- The first 25 subjects could be classified in 12 out of 90 groups, while only 6 out of these 12 groups would cover 76% of all subjects (Table 7.18a).
- The first 50 subjects (actually 49 – *Subject 31* was excluded) measured by 22nd June 2011, could be classified in 22 out of 90 groups, while only 10 out of these 22 groups would cover 75.5% of all subjects (Table 7.18b).
- Overall, all 75 subjects (actually 74 – *Subject 31* was excluded) measured by 12th June 2012, could be classified in 28 out of 90 groups, while only 13 out of these 28 groups would cover 79.72% of the whole sample (Table 7.18c).

Table 7.18a

SUBJECT CLASSIFICATION IN 90 GROUPS

SUBJECT CLASSIFICATION ACCORDING TO SCOLIOSIS LOCATION	SUBJECT BODY SIZES & CURVE SIZES														
	1XS	1S	1M	1L	1XL	2XS	2S	2M	2L	2XL	3XS	3S	3M	3L	3XL
RIGHT/LEFT - S - CERVICO-THORACIC											1				
RIGHT/LEFT - S - THORACO-LUMBAR			3	3	1		1	4		1			2	1	
RIGHT/LEFT - S - CERVICO-THORACO-LUMBAR															
RIGHT/LEFT - C - CERVICAL															
RIGHT/LEFT - C - THORACIC		3	4	1											
RIGHT/LEFT - C - LUMBAR															

SAMPLE SIZE OF 25 SUBJECTS

SUBJECT CLASSIFICATION PERCENTAGE IN 90 GROUPS

SUBJECT CLASSIFICATION ACCORDING TO SCOLIOSIS LOCATION	SUBJECT BODY SIZES & CURVE SIZES														
	1XS	1S	1M	1L	1XL	2XS	2S	2M	2L	2XL	3XS	3S	3M	3L	3XL
RIGHT/LEFT - S - CERVICO-THORACIC											4%				
RIGHT/LEFT - S - THORACO-LUMBAR			12%	12%	4%		4%	16%		4%			8%	4%	
RIGHT/LEFT - S - CERVICO-THORACO-LUMBAR															
RIGHT/LEFT - C - CERVICAL															
RIGHT/LEFT - C - THORACIC		12%	16%	4%											
RIGHT/LEFT - C - LUMBAR															

SAMPLE SIZE OF 25 SUBJECTS

	UP TO 5%
	FROM 5% TO 10%
	FROM 10% TO 20%

¹⁰⁶ The highlighted groups in tables 7.18abc represent the groups evaluated after the wearer trial.

Table 7.18b

SUBJECT CLASSIFICATION IN 90 GROUPS

SUBJECT CLASSIFICATION ACCORDING TO SCOLIOSIS LOCATION	SUBJECT BODY SIZES & CURVE SIZES														
	1XS	1S	1M	1L	1XL	2XS	2S	2M	2L	2XL	3XS	3S	3M	3L	3XL
RIGHT/LEFT - S - CERVICO-THORACIC		2		1	1			1	1		1				1
RIGHT/LEFT - S - THORACIO-LUMBAR		2	6	5	3		1	5	1	1		2	2	1	
RIGHT/LEFT - S - CERVICO-THORACO-LUMBAR															
RIGHT/LEFT - C - CERVICAL															
RIGHT/LEFT - C - THORACIC		5	5	1											
RIGHT/LEFT - C - LUMBAR	1														

SAMPLE SIZE OF 49 SUBJECTS

SUBJECT CLASSIFICATION PERCENTAGE IN 90 GROUPS

SUBJECT CLASSIFICATION ACCORDING TO SCOLIOSIS LOCATION	SUBJECT BODY SIZES & CURVE SIZES														
	1XS	1S	1M	1L	1XL	2XS	2S	2M	2L	2XL	3XS	3S	3M	3L	3XL
RIGHT/LEFT - S - CERVICO-THORACIC		4.08%		2.04%	2.04%			2.04%	2.04%		2.04%				2.04%
RIGHT/LEFT - S - THORACIO-LUMBAR		4.08%	12.24%	10.2%	6.12%		2.04%	10.2%	2.04%	2.04%		4.08%	4.08%	2.04%	
RIGHT/LEFT - S - CERVICO-THORACO-LUMBAR															
RIGHT/LEFT - C - CERVICAL															
RIGHT/LEFT - C - THORACIC		10.2%	10.2%	2.04%											
RIGHT/LEFT - C - LUMBAR	2.04%														

SAMPLE SIZE OF 49 SUBJECTS

	UP TO 5%
	FROM 5% TO 10%
	FROM 10% TO 20%

Table 7.18c

SUBJECT CLASSIFICATION IN 90 GROUPS




SUBJECT CLASSIFICATION ACCORDING TO SCOLIOSIS LOCATION	SUBJECT BODY SIZES & CURVE SIZES														
	1XS	1S	1M	1L	1XL	2XS	2S	2M	2L	2XL	3XS	3S	3M	3L	3XL
RIGHT/LEFT - S - CERVICO-THORACIC		3	3	1	1			1	1		1				1
RIGHT/LEFT - S - THORACIO-LUMBAR		5	12	6	3		3	6	1	1		2	3	1	
RIGHT/LEFT - S - CERVICO-THORACO-LUMBAR		2						1		1					
RIGHT/LEFT - C - CERVICAL															
RIGHT/LEFT - C - THORACIC		6	5	1	1								1		
RIGHT/LEFT - C - LUMBAR	1														

SAMPLE SIZE OF 74 SUBJECTS

SUBJECT CLASSIFICATION PERCENTAGE IN 90 GROUPS

SUBJECT CLASSIFICATION ACCORDING TO SCOLIOSIS LOCATION	SUBJECT BODY SIZES & CURVE SIZES														
	1XS	1S	1M	1L	1XL	2XS	2S	2M	2L	2XL	3XS	3S	3M	3L	3XL
RIGHT/LEFT - S - CERVICO-THORACIC		4.05%	4.05%	1.35%	1.35%			1.35%	1.35%		1.35%				1.35%
RIGHT/LEFT - S - THORACIO-LUMBAR		6.75%	16.21%	8.10%	4.05%		4.05%	8.10%	1.35%	1.35%		2.70%	4.05%	1.35%	
RIGHT/LEFT - S - CERVICO-THORACO-LUMBAR		2.70%						1.35%		1.35%					
RIGHT/LEFT - C - CERVICAL															
RIGHT/LEFT - C - THORACIC		8.10%	6.75%	1.35%	1.35%								1.35%		
RIGHT/LEFT - C - LUMBAR	1.35%														

SAMPLE SIZE OF 74 SUBJECTS

 UP TO 5%
 FROM 5% TO 10%
 FROM 10% TO 20%

7.6. Size Charts based on young women's with scoliosis body dimensions

After the preliminary classification of subjects, according to the *Greek generic sizes*, the aim of this research was to obtain body measurements, statistically analyze data and generate *Body Measurement Tables* and *Size Charts* based on subject classification, developing a sizing system, derived from *median body measurements* of women with scoliosis, classified in different scoliotic groups according to their type of scoliosis. This new sizing system would enable the construction of basic pattern blocks for garments more tolerant of bodies with scoliosis, providing a better garment fit and the potential to be used for mass customisation.

The small sample of 75 subjects aged 16-22, measured for this study, confirmed the difficulty of obtaining accurate measurements, selecting key dimensions and labelling sizes, even for such a small sample. The reason for using the *median* over the *mean* (average) measurements of the scoliotic groupings was that the *mean* is the arithmetic average of a group of scores, sensitive to extreme scores when population samples are small and often used with larger sample sizes, whereas the *median* is the middle score in a list of scores - the point at which half the scores are above and half the scores are below - less sensitive to extreme scores and, probably, a better indicator generally of where the middle of the class is achieving, especially for smaller sample sizes.

In the case of a normal distribution of the sample (this is the case for this research project, as it is also the most frequently assessed in statistics), when the data is perfectly normal, the *mean*, *median* and *mode* are identical. Moreover, they all represent the most typical value in the data set. However, as the data becomes skewed (by outliers) the *mean* loses its ability to provide the best central location for the data because the

skewed data is dragging it away from the typical value, whereas the *median* best retains this position and is not as strongly influenced by the skewed values¹⁰⁷.

The purpose of subject classification was to demonstrate the process of devising size charts by analysing raw data (body measurements of girls with scoliosis), to relate key aspects of sizing charts to raw data (relationships between body measurements), and to generate descriptive statistics analyses (mean, median, standard deviation, percentiles, etc) by raw data, which would be utilized to introduce five sizes for two different body size charts, based on *key dimensions*, for the two most populated groups of *subjects* with scoliosis - the Right S-type Thoraco-lumbar (**C₁R_RT_SS_{TL}** - Table 7.29, pp.297) and the Right C-type Thoracic (**C₁R_RT_CS_T** - Table 7.30, pp.298) scoliotic groups¹⁰⁸.

Thus, *descriptive summary statistics* were utilised for the two most populated scoliotic groups, while *means, medians, standard deviations, minimum and maximum* values, and *percentiles* were calculated (Appendix B - Tables 7.19abc & 7.20abc), in order to determine size range, size codes and grading increments (Beazley, 1998; Otieno, 2008; Vronti, 2005). *Pearson's correlation coefficients* were also calculated, based on *Principal Component Analysis* (Tables 7.21 - 7.21a, 7.22 - 7.22a & 7.23 - 7.23a, Appendix B), in order to determine relationships between body dimensions and select *key dimensions* (Tables 7.24, 7.25 & 7.26 - Appendix B) for the formulation of two different size charts with a defined size range and grading increments that are reliable to utilisation by consumers with scoliosis, retailers and manufacturers (Tables 7.27 & 7.28 - Appendix B). The efficacy of the above two size charts was primarily verified using *frequency tables* (Tables 7.33. 7.34 & 7.35, pp.302-303), comparing the distribution of the scoliotic sample

¹⁰⁷ <https://statistics.laerd.com/statistical-guides/measures-central-tendency-mean-mode-median.php> (Accessed 29th May 2013)

¹⁰⁸ The rest of the 180 scoliotic groups were represented by only a limited number of subjects - the maximum number of subjects being i.e. five for the **C₂R_RT_SS_{TL}** group – not adequate for devising a new size chart.

according to the initial *Greek Generic Size Chart*'s five sizes (Table 7.12, pp.272) versus the two devised size charts' five sizes (Tables 7.29 & 7.30, pp.297-298).

7.6.1. Descriptive Statistics

The method employed was based on the approach used by Gupta & Gangadhar's statistical model for developing body size charts for garments (2004:458-469), followed by Otieno (2008:63-82) and the MMU model's step-by-step process in generating size charts by utilizing anthropometric data.

At first, raw data were collated and cleaned by evaluating outliers (Tables 7.27 & 7.28 - Appendix B), while descriptive summary statistics provided a medium for initial evaluation of data generated by this survey's database. Size charts were developed by *means*, *medians* and *standard deviations* of all the variables, while for a great number of measurements, *median* and *mean* (average) values were almost identical (Tables 7.19a & 7.20a - Appendix B). Furthermore, percentiles were selected because they had implications for each size (Tables 7.19abc & 7.20abc - Appendix B). The 50th percentile was also the *median*, identifying the base size (size **M**), whereas a larger percentile would produce a larger fit and a smaller percentile a smaller fit.

Tables 7.19a and 7.20a show variations of the base size, for the two most populated scoliotic groups, when the 25th, 50th, 75th and 85th percentiles are selected. In this research, the **base size** is the generic size **M**, and using this as base size for the 50th percentile, the standard deviation is utilised to create size steps in notations of 1, 2 and 2.5 to the right and left of the base size value (in this case, 2.5 divisions are catered for on each side of the median). By subtracting one standard deviation value from the median, the next small size (size **S**) is determined, while by adding the value of one standard deviation to the median, the next large size (size **L**) is determined. Statistically, only 2.5% coverage is left above size **XL** and 2.5% below size **XS**. Sizes **XXL** and **XXS**

could be demarcated by adding or subtracting 2.5 standard deviation values to the median, respectively. Based on the values for sizes **XXS - XXL** for all the variables, a body measurement table can be developed, thereby creating a size range (Tables 7.27 & 7.28 - Appendix B).

COMPARING AND DEFINING MEDIAN MEASUREMENTS

Given that the 'Subject Group Median Measurements' Table (Appendix B) indicates the *median measurement values* for every different size sub-group of each populated scoliotic group (36 out of 180 groups)¹⁰⁹, **it would be interesting to study and compare the difference between *median values* derived directly by each size sub-group belonging to the same scoliotic group, separately, and *median values* obtained by adding or subtracting the standard deviation, to and from, the *median values* for each scoliotic group (including all sizes)**, for the two most populated scoliotic groups (Tables 7.19a and 7.20a - Appendix B, for the **C₁R_RT_CS_T** and the **C₁R_RT_SS_{TL}** group, respectively).

C₁R_RT_CS_T GROUP

On the one hand, Table 7.19a (**C₁R_RT_CS_T** group in sizes **S, M, L**) indicated that in certain cases there were no differences in *median values* for size **S**. In most cases, differences in *median values* lied between 0.10cm to 2.75cm (rather trivial), while the *median values* derived separately by size **S** sub-group demonstrated higher values, in general. For nine measurements the difference in median values exceeded 3cm, reaching 6.25cm at the crotch length.

In cases where measurements demonstrated differences in *median values* for size **M**, these lied between 0.10cm to 2cm, the *median values* derived separately by size **M** sub-

¹⁰⁹ When only one subject is classified in a certain scoliotic group, the measurement values for this group are the measurement values obtained from this subject.

group demonstrating higher values, in general. For eight measurements the difference in *median values* exceeded 2.5cm, reaching 3.75cm at the right upper-thigh circumference. Overall, the majority of *median* measurements obtained by adding the standard deviation to the *median values* for the whole group were higher than the *median values* for size **L** sub-group, while in most cases, differences in *median values* lied between 0.10cm to 2.75cm. For seventeen measurements, however, the difference in *median values* exceeded 3cm, reaching 7.25cm at the crotch length (meas. 46) and the under-bust circumference (meas. 14).

It is noticeable, at this point, that the measurement, i.e. of the crotch length (meas. 46) demonstrates a minimum difference between the two differently obtained *median values* in size **M**, whereas, concerning size **S**, the *median value* derived separately by size **S** sub-group exceeded the second *median* by 6.25cm, and concerning size **L**, the *median value* obtained by adding the standard deviation to the *general median* exceeded the first, *sub-group median* by 7.25cm.

C₁R_RT_SS_{TL} GROUP

On the other hand, Table 7.20a (**C₁R_RT_SS_{TL}** group in sizes **S**, **M**, **L**, **XL**) also indicated that in certain cases there were no differences in *median values* for size **S**. In most cases, differences in *median values* lied between 0.10cm to 2.75cm (rather trivial), while the *median values* derived separately by size **S** sub-group, demonstrated higher values, in general. For nineteen measurements the difference in *median values* exceeded 3cm, reaching 5cm at the total height of right and left neck points (front / back).

The majority of measurements demonstrated no difference in *median values* for size **M**, while in cases where there were differences, these lied between 0.10cm to 1.5cm - the *median values* derived separately by size **M** sub-group demonstrating higher values, in

general. The difference in *median values* exceeded 2cm, reaching 2.5cm, only in two cases: the left mid-thigh circumference and the midriff circumference.

On the contrary, the majority of *median* measurements derived from adding the standard deviation to the *median values* for the whole group were higher than the *median values* for size **L** sub-group, while, in most cases, differences in *median values* lied between 0.10cm to 2.75cm. For twenty-five measurements the difference in *median values* exceeded 3cm, reaching 7.25cm at the under-bust circumference.

In general, most of the measurements derived from adding the standard deviation to the *median values* for the whole group were higher than the *median values* for size **XL** sub-group, while, in most cases, differences in *median values* lied between 0.10cm to 2.75cm. For twenty-three measurements the difference in *median values* exceeded 3cm, reaching 10.5cm at the total height of right shoulder point (front / back) and 12.5cm at the total height of left shoulder point (front / back).

Such extreme value differences (i.e. 12.5cm), between the two different ways of obtaining *median values*, could be perfectly justified, owing to the inadequate sample of subjects classified in the size **XL** sub-group (only 2 subjects).

In conclusion, there was a general tendency, concerning both scoliotic groups, of the sub-group median values being higher in sizes below size **M** and lower in sizes above size **M**.

Nevertheless, the above findings established the validity of the theoretical model, used by Gupta & Gangadhar (2004:458-469) and Otieno (2008:63-82), for developing a step-by-step process in generating size charts by utilizing anthropometric data.

Therefore, ***median measurements obtained by adding or subtracting the standard deviation to and from the median values for a certain scoliotic group (including subjects from all sizes) were more appropriate to use, compared to median***

measurements derived directly by each size sub-group belonging to that scoliotic group, separately, in order to design basic pattern blocks for this research project.

7.6.2. Principal Components (PCA)

A Principal Component Analysis was carried out in order to reduce the number of variables and to detect the structure in the relationships between variables, comparing three different data sets: the whole scoliotic sample, the **C₁R_RT_SS_{TL}** group and the **C₁R_RT_CS_T** group.

WHOLE SAMPLE

According to the *scree plot* of the *eigenvalues* and their cumulative percentages (Appendix B – Table 7.21), the first five factors F1-F5 (principal components), accounting for 66.23% of the total variability in the whole sample data set, were identified. Based on the interrelationships existing in the whole sample data set, the principal components were:

1. *Principal Component 1* has strong correlations (≥ 0.76) with most girth-related dimensions, i.e. high-bust, full-bust, under-bust, midriff, waist, high-hips, hips, biceps circumferences, elbow circumferences, right wrist circumference, crotch length, upper-thigh circumferences, left mid-thigh circumference and both knee circumferences, as well as with one height-related upper body dimension, the nape-to-bust distance, on both left and right side. PC 1 also has partial correlations (≥ 0.5 and ≤ 0.75) with height and certain height-related upper body dimensions, i.e. left and right dress length-to-knee, front and back right / left full bodice lengths, etc.
2. *Principal Component 2* has only partial correlations (≥ 0.5 and ≤ 0.75) with height and most height-related upper body dimensions, i.e. left and right dress length-to-

knee, front and back right / left full bodice lengths, C1 to C3, C2 to C3, bust point heights, centre front bodice, left/right nape-to-waist, side seams length-to-waist, nape-to-waist centre back, underarm lengths, elbow-to-underarm lengths, back left / right shoulder slopes, height of neck points, and height of shoulder points.

3. *Principal component 3* has only partial correlations (≥ 0.5 and ≤ 0.75) with height-related dimensions concerning the arms and legs, i.e. left and right arm lengths and underarm lengths, outside and inside leg lengths, front and back waist-to-floor heights and left / right knee positions (distance to floor).
4. *Principal component 4* has only partial correlations (≥ 0.5 and ≤ 0.75) with four height-related lower body dimensions concerning the waist-to-hips distance: front, back, left and right hip depths.
5. *Principal component 5* has only partial correlations (≥ 0.5 and ≤ 0.75) with five width-related dimensions concerning the shoulders, i.e. total back and centre back-to-right shoulder tip width, left and right shoulder lengths and neck point to C2

C₁R_RT_SS_{TL} GROUP

After observing the *scree plot* of the *eigenvalues* and their cumulative percentages (Appendix B – Table 7.22), the first five factors F1-F5 (principal components), accounting for 68.29% of the total variability in the C₁R_RT_SS_{TL} data set, were identified. Based on the interrelationships existing in the C₁R_RT_SS_{TL} data set, these were:

1. *Principal component 1* has strong correlations (≥ 0.76) with all girth-related upper body dimensions, i.e. high-bust, full-bust, under-bust, midriff, waist, high-hips, right biceps circumference and partial correlations (≥ 0.5 and ≤ 0.75) with other girth-related dimensions, such as hips, armhole circumferences, elbow circumferences, wrist circumferences, upper-thigh circumferences, mid-thigh

circumferences and knee circumferences, as well as partial correlations (≥ 0.5 and ≤ 0.75) with height and most height-related dimensions.

2. *Principal component 2* has strong correlations (≥ 0.76) with two height-related upper body dimensions concerning the left side - the back left full bodice length and the left underarm length – as well as partial correlations (≥ 0.5 and ≤ 0.75) with height and other height-related upper body dimensions, i.e. front left / right and back right full bodice lengths, centre front bodice, left nape-to-waist length, right side seam length-to-waist, nape-to-waist centre back, right underarm length, elbow-to-underarm lengths, front left and back left/right shoulder slopes, height of neck points, height of shoulder points, C2 to C3, etc. It has also partial correlations (≥ 0.5 and ≤ 0.75) with certain height-related lower body dimensions, i.e. front left dress length-to-knee and left/right inside leg lengths.
3. *Principal component 3* has only partial correlations (≥ 0.5 and ≤ 0.75) with certain height-related upper body dimensions, i.e. front left / right full bodice lengths, left side seam length to waist, left / right shoulder-to-bust and left shoulder point, as well as with certain height-related lower body dimensions, i.e. front and back waist-to-floor, left / right outside leg lengths, left / right inside leg lengths and left / right knee positions (distance to floor).
4. *Principal component 4* has only partial correlations (≥ 0.5 and ≤ 0.75) with certain girth-related lower body dimensions, such as front / back left hip widths, left / right mid-thigh circumferences, right knee circumference and left / right calf and ankle circumferences.
5. *Principal component 5* has only partial correlations (≥ 0.5 and ≤ 0.75) with three upper body dimensions, concerning mostly the right side, such as the right armhole (scye) depth, the total and right back width and the total back and centre back-to-right shoulder tip width.

C₁R_RT_CS_T GROUP

After observing the *scree plot* of the *eigenvalues* and their cumulative percentages (Appendix B – Table 7.23), the first five factors F1-F5 (principal components), accounting for 90.34% of the total variability in the **C₁R_RT_CS_T** data set, were identified. Based on the interrelationships existing in the **C₁R_RT_CS_T** data set, these were:

1. *Principal component 1* has strong correlations (≥ 0.76) with most girth-related and width-related dimensions, i.e. high-bust, full-bust, under-bust, midriff, waist, high-hips, hips, biceps, upper-thigh, mid-thigh, knee and calf circumferences, front and back shoulder tip widths, shoulder lengths, neck point to C2, total and centre front-to-right chest widths, as well as certain height-related dimensions: the right dress length-to-knee, the front left and right full bodice lengths, the left / right nape-to-bust lengths, the right nape-to-waist length, the front left shoulder slope and the back waist-to-floor height. It has also partial correlations (≥ 0.5 and ≤ 0.75) with height and other height-related dimensions, i.e. left dress length-to-knee, centre front bodice, right scye depth, front right and back left-right shoulder slopes, left/right shoulder-to-bust lengths, height of neck points and height of shoulder points, outside leg lengths and inside leg lengths.
2. *Principal component 2* has strong correlations (≥ 0.76) with only one width-related dimension concerning the left side, the left across back, and certain height-related dimensions, such as left side seam length-to-waist, right / left elbow to underarm lengths, right / left neck point heights, right shoulder point height, crotch length, C1 to C3 and C2 to C3. It has also partial correlations (≥ 0.5 and ≤ 0.75) with other height-related dimensions, i.e. left/right dress length-to-knee, back left/right full bodice lengths, bust point heights, centre front bodice, left nape-to-bust, right side seam length to waist, nape-to-waist centre back, front left

and back left/right shoulder slopes, left/right shoulder-to-bust lengths, inside leg lengths, etc.

3. *Principal component 3* has only partial correlations (≥ 0.5 and ≤ 0.75) with certain girth-related dimensions, such as left back hip width, right ankle circumference and left / right armhole circumferences, as well as with certain height-related dimensions, such as right bust radius, nape-to-waist centre back, left/right body rises (seated), right knee position and left / right height of shoulder slopes.
4. *Principal component 4* has strong correlations (≥ 0.76) with only one height-related dimension concerning the arms – the left/right elbow heights - and partial correlations (≥ 0.5 and ≤ 0.75) with other height-related dimensions, such as left strap front, left scye depth and left/right arm lengths. It has also partial correlations with certain width-related dimensions such as total chest width, front right full-bust width, centre front to right bust-point distance, left/right elbow circumferences and left hand circumference.
5. *Principal component 5* has strong correlations (≥ 0.76) with only one height-related dimension concerning the lower body – the left/right body rises (seated) – and partial correlations (≥ 0.5 and ≤ 0.75) with another height-related dimension concerning the upper body - the left/right bust point heights. It has also partial correlations with one width-related dimension – the total back and left across back width.

Principal Components (factors) found for the whole sample (Tables 7.21a & 7.24 - Appendix B) were compared to principal components found for the two most populated scoliotic groups: the **C₁R_RT_SS_{TL}** group (Tables 7.22a & 7.25 - Appendix B) and the **C₁R_RT_CS_T** group (Tables 7.23a & 7.26 - Appendix B). The findings provided the framework for the development of two size charts (Tables 7.27 & 7.28 - Appendix B) with

the utilisation of *median values* and *standard deviations of 37 important variables*, in order to classify young women belonging to the two most populated scoliotic groups, thus, identifying the two most common types of scoliosis.

7.6.3. Key Dimensions

The next step was to determine the *key dimensions* that would be used by manufacturers, retailers and consumers with scoliosis in recognizing and selecting a size. *Key dimensions* are measurements used to denote a garment size, determining relationships between variables, and are assessed using the correlation coefficients (Gupta & Gangadhar, 2004:458-469), based on the strength of their relationship and the number of correlations with most other variables (below 0.5: no relationship, 0.5-0.75: *mild or moderate relationship*, above 0.76: *strong relationship*) (Otieno, 2008:74).

WHOLE SAMPLE

Based on the interrelationships existing in the whole sample data set, from the table of correlation coefficients (Table 7.21a - Appendix B), seven dimensions (high-bust, bust, midriff, waist, left / right biceps, high-hip and hip circumferences) have the highest number of strong correlations with other variables (Table 7.24 - Appendix B).

C₁R_RT_SS_{TL} GROUP

Based on the interrelationships existing in the C₁R_RT_SS_{TL} data set, from the table of correlation coefficients (Table 7.22a - Appendix B), eight dimensions (bust, under-bust, midriff, waist, high-hip and hip circumferences, both left / right height of neck points and right biceps circumference) have the highest number of strong correlations with other variables (Table 7.25 - Appendix B).

C₁R_RT_CS_T GROUP

Based on the interrelationships existing in the **C₁R_RT_CS_T** data set, from the table of correlation coefficients (Table 7.23a - Appendix B), nine dimensions (high-bust, bust, high-hip and hip circumferences, back waist widths, right back high-hip width, right hip width, total front shoulder tip width and centre back to right shoulder tip width, left/right upper-thigh circumferences, left/right mid-thigh circumferences and left knee circumference) have the highest number of strong correlations with other variables (Table 7.26 - Appendix B).

The dimensions which appeared common in all the above three data sets, having the highest number of strong correlations with other variables, were the industry standard principle body measurements, confirmed by the PCA: the **bust**, **waist** and **hip circumference**. In addition, since **height** was also common among all three data sets, demonstrating partial correlations with other variables (Tables 7.21, 7.22 & 7.23 - Appendix B), it was also used as a key dimension for the two final size charts (Tables 7.29 & 7.30, below):

Table 7.29

C₁R_RT_ST_L MEDIAN SIZE	HEIGHT (cm)	HIPS (cm)	WAIST (cm)	BUST (cm)
X SMALL	151 - 157.5	84 - 92	59 - 66	74 - 81
SMALL	158 - 164.5	92.5 - 100.5	66.5 - 73.5	81.5 - 88.5
MEDIUM	165 - 171.5	101 - 110	74 - 81	89 - 96
LARGE	172 - 178.5	110.5 - 119.5	81.5 - 88.5	96.5 - 103.5
X LARGE	179 - 185.5	120 - 129	89 - 96	104 - 111

Table 7.30

C₁R_RT_CS_T MEDIAN SIZE	HEIGHT (cm)	HIPS (cm)	WAIST (cm)	BUST (cm)
X SMALL	157 - 162	81 - 88	58 - 63	73 - 79
SMALL	162.5 - 167.5	88.5 - 95.5	63.5 - 68.5	79.5 - 85.5
MEDIUM	168 - 173	96 - 103	69 - 75	86 - 92
LARGE	173.5 - 178.5	103.5 - 110.5	75.5 - 81.5	92.5 - 99.5
X LARGE	179 - 184	111 - 119	82 - 88	100 - 107

The proposed size charts (Tables 7.29 & 7.30) indicate only body measurements, while the actual garment measurements could be derived, by incorporating the appropriate ‘*wearing ease*’ or ‘*design ease*’ allowance for each garment style.

7.6.4. Intersize Intervals and Drop Values

From Tables 7.29 and 7.30, above, it is evident that there are a few noticeable differences regarding the *intersize intervals* and the *bust-to-hip drop values* between the two size charts.

In terms of *height*, the **C₁R_RT_SS_{TL}** group interval between the five sizes is 6.5cm, whereas the **C₁R_RT_CS_T** group *intersize interval* is 5cm.

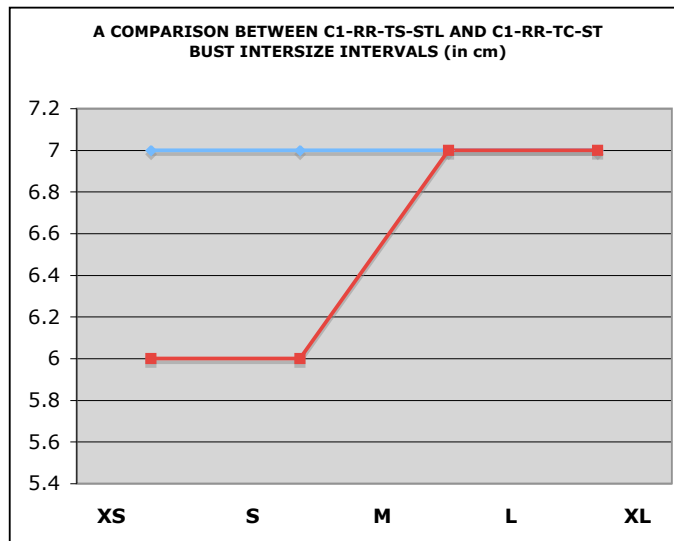
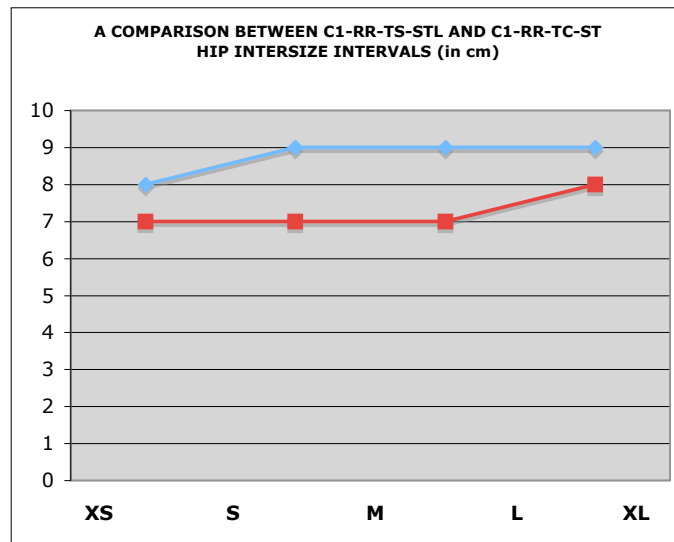
In terms of *hip circumference*, the **C₁R_RT_SS_{TL}** group *intersize interval* is 8cm up to size **M** and 9 cm for the larger sizes, whereas the **C₁R_RT_CS_T** group interval is 7cm for the first four sizes, becoming 8cm only for size **XL**.

In terms of *waist circumference*, the **C₁R_RT_SS_{TL}** group *intersize interval* is 7cm for all sizes, whereas the **C₁R_RT_CS_T** group interval is 5cm from size **XS** to size **S** and 6cm for the rest of the sizes.

Overall, in terms of *bust circumference*, the **C₁R_RT_SS_{TL}** group *intersize interval* is also 7cm for all sizes, whereas the **C₁R_RT_CS_T** group interval is 6cm for the first three sizes and 7cm for sizes **L** and **XL**.

A COMPARISON BETWEEN **C₁R_RT_SS_{TL}** (Table 7.29) AND **C₁R_RT_CS_T** (Table 7.30)
INTERSIZE INTERVALS (a) FOR HIPS and (b) FOR BUST,
IN RELATION TO THE FIVE GENERIC SIZES

Table 7.31a-b



C1RrTsStl

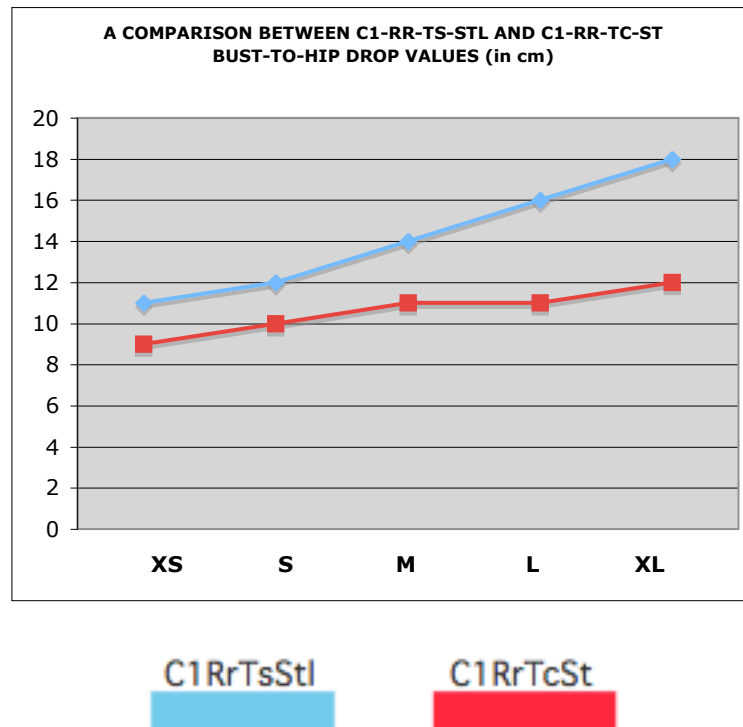
C1RrTcSt

Table 7.31ab demonstrates the ‘hip’ and ‘bust’ *intersize intervals* for the two different size charts compared, in relation to the generic sizes used in this study. Blue lines indicate hip and bust intersize intervals in the **C₁R_RT_SS_{TL}** size chart, while red lines in the **C₁R_RT_CS_T** size chart.

On the one hand, Table 7.31a shows that the **C₁R_RT_SS_{TL}** *hip intersize intervals* are the highest, remaining the same for the larger sizes, whereas the **C₁R_RT_CS_T** *hip intersize interval* increases for the largest size (**XL**). On the other hand, Table 7.31b shows that the **C₁R_RT_SS_{TL}** *bust intersize intervals* are also the highest, being the same for all sizes, whereas the **C₁R_RT_CS_T** *bust intersize intervals* demonstrate a gap from 6cm to 7 cm after size **M**.

A COMPARISON BETWEEN **C₁R_RT_SS_{TL}** (Table 7.29) AND **C₁R_RT_CS_T** (Table 7.30)
BUST-TO-HIP DROP VALUES,
IN RELATION TO THE FIVE GENERIC SIZES

Table 7.32



In addition, Table 7.32 indicates the *bust-to-hip drop value* for the two different scoliotic groups' size charts compared, in relation to the generic sizes used in this study. The *bust-to-hip drop value* in the **C₁R_RT_SS_{TL}** size chart ranged from 11cm for size **XS** (the smallest size), increasing gradually from 1cm for the second size (**S**) to 2cm for each larger size, reaching 18cm for size **XL** (the largest size) (Table 7.29, pp.297). In the **C₁R_RT_CS_T** size chart the *drop value* ranged from 9cm for size **XS** (the smallest size), increasing gradually 1cm up to size **M**, remaining the same (11cm) for size **L** and reaching 12cm for size **XL** (the largest size) (Table 7.30, pp.298).

Hence, it is evident from Table 7.31ab that **none of the two scoliotic groups demonstrate the same intersize intervals for bust and hips**, as many current sizing systems, used today in industry, do - i.e. the **BSI** sizing system uses a 4cm intersize interval for both bust and hips (Table 7.8, pp.265). Moreover, Table 7.32 indicates that **the bust-to-hip drop values of the two scoliotic groups demonstrate a totally different patterning across the five sizes**, the **C₁R_RT_SS_{TL}** *drop values* being the highest, having a steeper ascending tendency towards the larger sizes than the *bust-to-hip drop values* of the **C₁R_RT_CS_T** group.

To conclude, the above findings based on anthropometric data point towards the need for developing different size charts for different types of scoliosis.

7.6.5. Frequency Tables

The following frequency tables (Tables 7.33, 7.34 & 7.35) demonstrate a better subject distribution into the five generic sizes, after comparing the subject distribution initially using the '*Greek Generic*' size chart (Table 7.12, pp.270) and, later, using the two different size charts for the two most populated scoliotic groups, in this research (Tables 7.29 & 7.30, pp.297-298).

As established from Table 7.16, the Size Distribution Lines (into five sizes) of the ‘Greek National Survey’ sample and the ‘Greek Scoliotic’ sample are quite similar. Therefore, I attempted a more analytical distribution of the scoliotic sample into the five generic sizes, in relation to *height* and *hip*, *waist* and *bust* circumferences (key dimensions).

Table 7.33 depicts a rather normal distribution of the whole scoliotic sample in the five generic sizes, in terms of *height*, *hip* and *bust* circumference (based on the Greek National Survey), although it is evident that the *waist* circumferences of the scoliotic sample do not conform to the *waist* circumferences designated to the ‘Greek National Survey’s’ sample – the former being quite smaller than the latter.

Table 7.33

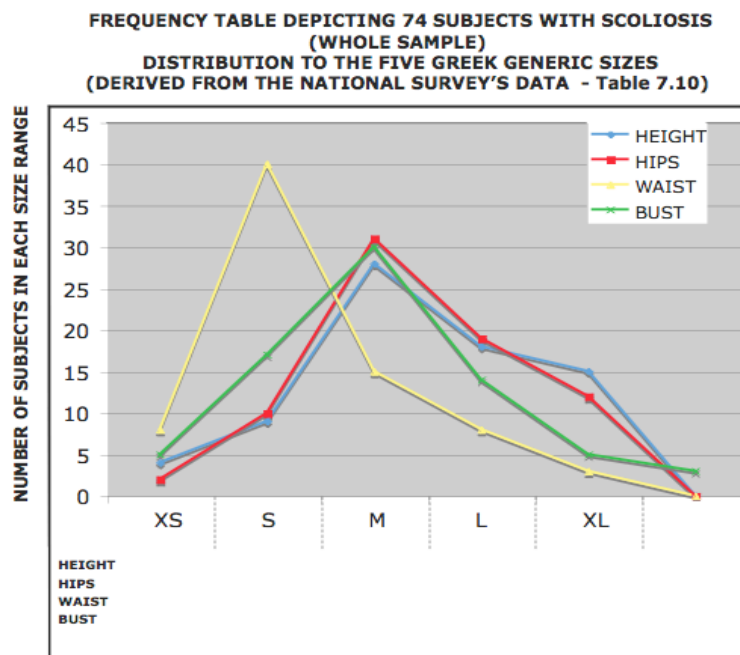


Table 7.34

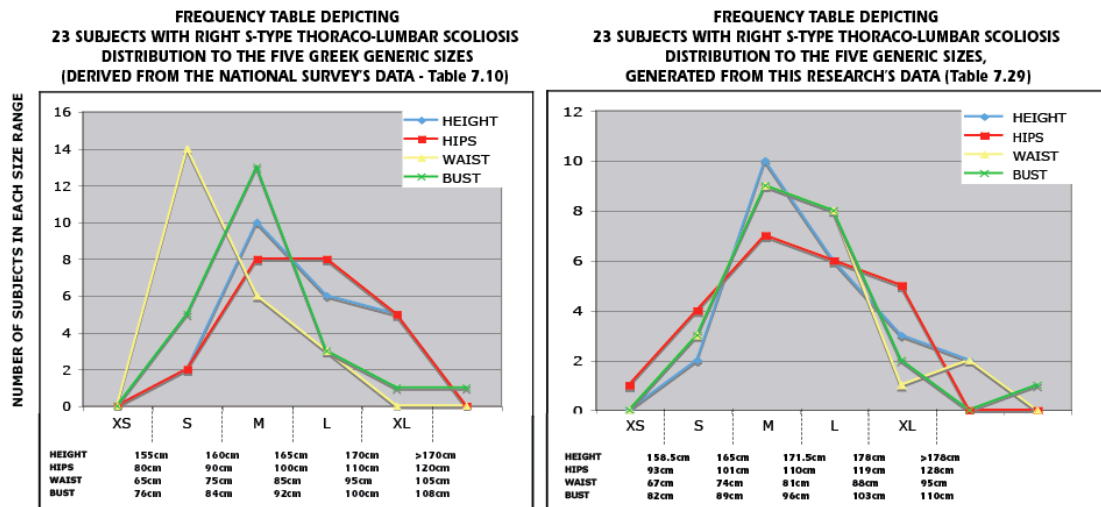
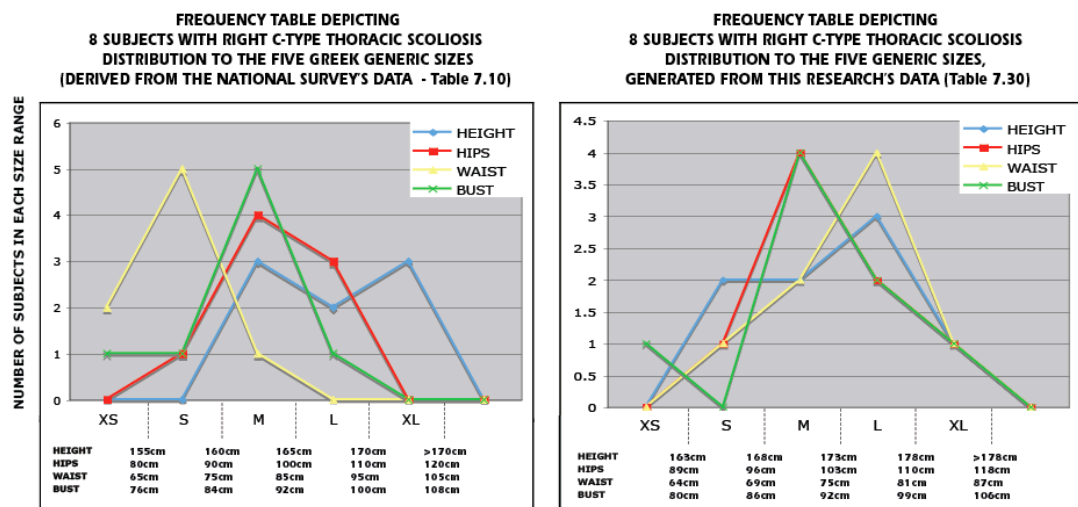


Table 7.35



Tables 7.34 and 7.35 depict the Size Distribution Lines (into five sizes) of the $C_1R_RT_S S_{TL}$ and the $C_1R_RT_C S_T$ group, respectively, in relation to *height* and *hip*, *waist* and *bust* circumferences (key dimensions) – firstly in the five ‘Greek generic sizes’ and secondly,

in the five sizes derived from the sizes charts developed for this study (Tables 7.29 & 7.30, pp.297-298, respectively). Given the small number of subjects (especially for the **C₁R_RT_cS_T** group), the right figures, in both tables, indicate a far more acceptable subject distribution into the five generic sizes, implying that there is definitely a need for the development of new sizing systems that would benefit young women with scoliosis of the spine.

7.6.6. Pattern and Garment Sizing

Size widths were determined by demarcating the boundaries between sizes (Beazley, 1998, 1999; Otieno, 2008), while grades were determined by the values between sizes and by considering realistic increments that manufacturers would select (Tables 7.27 & 7.28 - Appendix B). Determining lower and upper limits is paramount in defining size width and can affect the grading increments used (Otieno, 2008:75). The lower and upper limits and boundary demarcation for all sizes are shown in Tables 7.27 and 7.28 (Appendix B) for size chart Tables 7.29 and 7.30, respectively.

Garment size charts could, then, be developed based on the addition of ease allowances for variables (Beazley, 1998; Gupta & Gangadhar, 2004), whose amounts are not usually comparable between manufacturers, and who apparently use them based on arbitrary decisions. The ease allowances used in the basic patterns for this study were the same for all the sizes, generated from the ease allowances used for **UK size 12** basic pattern blocks by W. Aldrich (Table 8.1 – Appendix C).

Overall, in order to validate the efficacy of these size charts, based on young women's with scoliosis body dimensions (Tables 7.19c & 7.20c – Appendix B), a measure known as *the 'aggregate loss of fit'* – used by Gupta and Gangadhar (2004:467) – was

calculated for each subject that was classified in the two most populated scoliotic groups, separately (Chapter 10.1:361, see Table 10.1 – Appendix E).

These findings were further established by wearer trials and evaluations (by the researcher), based on comments made by the subjects themselves (Appendix E).

Thus, a conceptual framework that relates the new size charts to basic pattern block development and garment fit issues to overall consumer satisfaction with clothing sizing was developed based on survey data from the questionnaire, on body cathexis, brand awareness and individual preferences in clothing styles.

Chapter 8

Designing Basic Pattern Blocks for Adolescent Girls with Scoliosis

Patternmakers use anthropometric measurements (size specifications) to develop pattern blocks that are intended to produce the desired design of a garment, after evaluating the sample garment (toile).

A typical set of basic pattern blocks for women's garments include a bodice, a sleeve, a skirt and a pair of trousers. The desired fit of a garment is defined by the function, for which, it is intended and can be achieved by developing a suitable basic block generated from body dimensions.

In this study, **Close-fitting Basic Pattern Blocks** were used, owing to the fact that such blocks, **having the minimum amount of wearing ease required, would better indicate the areas of a garment that are mostly affected by body asymmetry due to scoliosis of the spine.**

Hence, the set of basic pattern blocks used, were:

- **The basic close-fitting bodice block** (hip block) by Winifred Aldrich (1994: 18,19,33)
- **The basic close-fitting one-piece dress block** by Winifred Aldrich (1994: 18,19,33,34)
- **The one-piece narrow sleeve block** by Winifred Aldrich (1994: 26,27)
- **The tailored skirt block** by Winifred Aldrich (1994: 56,57)
- **The basic trouser block** by Winifred Aldrich (1994: 76,77)

From the above four basic blocks, the *bodice block* and the *dress block*, which cover the upper torso - and thus, the rib hump due to scoliosis - were adapted, in order to accommodate a drafting method of asymmetric patterns to fit female bodies with scoliosis (Figures 8.3 and 8.5, pp. 316-317, respectively).

8.1. Determining the Basic Pattern Blocks' Ease Allowance

A *garment pattern* is often developed using a construction method, allowing at least the minimum levels of ease to satisfy comfort and function. However, current construction methods rarely explicitly state the levels of ease incorporated into the pattern, making it difficult to retain objective controls (Gill & Chadwick, 2009:23-31).

Ease is the critical concept related to garment construction and, therefore, to garment fit and garment sizing, while the amount of *ease* required for comfort, movement and an attractive appearance depends on the clothing design, the type and style of a garment, the fabric, the figure, the occasion where the clothing will be worn and, of course, personal preference (Rasband & Liechty, 2006:36). Thus *garment ease* includes, *wearing ease* and *design ease* (see Glossary, p. v).

As Gill and Chadwick (2009) point out, only a few sources exist enabling the recognition of ease requirements in the pattern/garment and when guidance on ease is presented, there is little rationale as to how it has been established, or what contributes to its definition, suggesting that current methods of pattern construction can be modelled more effectively, recognising the geometric nature on which they are based. The construction of a garment pattern requires satisfaction of complex variables to ensure finished garments fit and function correctly. Current pattern construction systems rely heavily on trial and error for their satisfaction, with little objective indication of ease requirements or insight into pattern philosophy, while they could combine anthropometric measurements,

pattern construction and human movement to investigate functional change and provide guidance on functional ease requirements to enable better fitting and functioning garments (Gill & Chadwick, 2009:23-31).

Nevertheless, there have been serious attempts towards quantifying ease in order to provide a system to determine the appropriate ease values for constructing well-fitting garments. Kirk and Ibrahim (1966:37-47) suggested that skin stretch during physical activity should be considered when evaluating stretch fabrics' performance for clothing design, while Petrova et al. (2003) measured the percentage change of waist, hip and thigh circumferences, as well as crotch length after sitting, and found that it increased with the body mass index (BMI) of the participant measured. Moreover, another study by Petrova and Ashdown (2012) has shown that the difference between the circumferences in a relaxed state and after taking a deep breath of the individual, in a garment fit trial, are used to calculate the minimum ease amounts necessary at the bust and waist for upper-torso garments (Petrova & Ashdown, 2012:270).

Overall, Gill (2011:228-241) has pointed out that recognition of the numerical nature of the pattern, suggests the need to quantify the coincident variables of ease, to achieve greater control over garment fit and function, while Petrova and Ashdown (2008:227-252) have suggested that ease amounts ought to vary with size, the larger sizes usually requiring larger ease amounts. Standard garment sizing practices, however, still utilize methods that effectively add constant ease amounts across all sizes. In a more recent study, the same researchers (Petrova & Ashdown, 2012:267-284) found out that a size-dependent ease grading method has the potential to produce better results in fitting a size range, than a constant ease grading method.

Fitting or Wearing ease (see Glossary) is the difference between a body measurement, such as *bust*, *waist*, or *hip* and the garment measurement in the same area. Thus, before

sewing a garment, the pattern needs to be measured from seam to seam, excluding seam allowances and space for pleats, tucks, or darts, in order to determine the amount of ease it has. Then, the actual body measurements should be compared to the total circumference measurement of the pattern. The difference is the actual amount of *wearing ease* the pattern has. With this knowledge, a pattern's ease allowance for a specific individual can be double-checked, so that it fits that specific individual's needs, figure shape, and lifestyle.

If there is not enough ease, clothing is strained, pulling and binding uncomfortably against the body, emphasizing body contours and figure variations - which means that a larger or a looser size (a fuller style) is needed, leading to *Design ease* (see Glossary). Once a block is established, individual garment designs are developed by adding the desired amount of '*style ease*' or '*design ease*' (Gill & Chadwick, 2009:23-31), which is the extra ease (or sometimes less ease), as compared to *wearing ease* that gives a garment its style.

In this research, Winifred Aldrich's basic blocks (1994) were used, owing to the fact that, as a student, I was taught the metric pattern cutting method (drafting method) described in her book, and I already possessed the particular basic blocks with the required amount of built-in ease (ease allowances for 154 body measurements are listed in Table 8.1 – Appendix C). These blocks were also tested on live models, on catwalk (November 1998), for a fashion design competition sponsored by '*Vilene*' - a large interlining supplier - and were found to provide a very good fit.

The amount of ease for each basic block, used in this research (Table 8.1 - Appendix C), was calculated after having measured and compared the pattern measurements to the actual body measurements at the same areas, for the specific body size, following the size chart for **UK size 12** (Aldrich, 1994:15). The difference was the actual amount of

wearing or fitting ease (see Glossary) of the pattern for the prototype garment (**UK size 12**) to fit the specific body (**UK size 12**).

Such basic blocks could have the potential to be used in the apparel industry, being derived from W. Aldrich's blocks [already used in the industry (Aldrich, 1994:7-10)], although clothing companies would develop their own blocks, tested on and addressed to their target customers.

To conclude, in this research project, I will try to demonstrate that a very good close-fit of simple, basic garments made up in woven 100% natural calico for individuals with scoliosis of the spine, can be achieved, owing to an accurate pattern design approach, which incorporates aesthetics, fundamental understanding of human comfort (wear comfort) and knowledge of how to design garments to maximise such comfort, based on reliable anthropometric data and adequate amounts of ease.

8.2. Adaptations of the Basic 'Blocks' originated by W. Aldrich

W. Aldrich's pattern cutting method, described in her book '*Metric Pattern Cutting*' (Third Edition, 1994), is mostly used as an introduction to the basic principles of pattern cutting, giving a few examples of the basic pattern blocks' application into garments (Aldrich, 1994:4). Therefore, the construction of the above basic blocks, described in Aldrich's book, needed a few adaptations in order to accommodate a drafting method, suitable to describe the step-by-step development of an asymmetric pattern to fit a body with scoliosis (see Tables 8.2-8.6, Appendix C).

Hence, Figure 8.1 shows the original close-fitting bodice (hip) block by W. Aldrich (1994:18-19,33). In Figure 6.3 (Chapter 6.5.1, pp.188), depicting the original close-fitting bodice block by W. Aldrich (1994:19), vertices 12 and 13 indicate a 5cm-length and 1cm-

width back shoulder dart, starting at mid-shoulder, for a better shaping around the shoulder blade. Figure 8.2 depicts the final close-fitting bodice block by W. Aldrich, after having eliminated these back shoulder-darts on both sides, in order to facilitate the pattern drafting procedure in the made-to-measure software, using less numbered vertices and, therefore, less grade rules (see Tables 8.2 & 8.3 – Appendix C).

Figure 8.3 depicts the final ‘bodice block’ with a mid-shoulder dart, on the right back pattern, only, starting at Landmark C1 (peak of the curvature) and ending at Landmark C2 (vertically up on the shoulder-line), adapted to provide the extra fabric needed for the prominent part, in order to accommodate the curvature due to scoliosis (given that the two most common types of scoliosis occur at the right back side) (Figure 6.6, Chapter 6.5.1, pp.194). For a better shaping around the left shoulder blade, the original back mid-shoulder dart can be re-designed (voluntarily), only on the left back pattern piece (as in Figure 8.1), since the right back pattern is already shaped due to the dart accommodating the scoliotic curve (Figure 8.3).

Overall, Figure 8.4 depicts the final bodice block when the right back shoulder dart, starting at C1, is manipulated and transferred, by 100%, to the right back mid-scy (RMidB), on the scoliotic curve’s side, for a better shaping and a more aesthetically pleasing result, while it would provide the same ease tolerance for embracing the scoliotic ‘hump’ curvature.

Respectively, Figure 8.5 depicts the final, adapted as the bodice, close-fitting one-piece basic dress block (originated by Aldrich, 1994:34) and Figure 8.6 depicts the one-piece narrow sleeve block (Aldrich, 1994:26-27).

Figure 8.7 depicts the tailored skirt block by W. Aldrich (1994:56-57), while Figure 8.8 depicts the basic trouser block by W. Aldrich (1994:76-77).

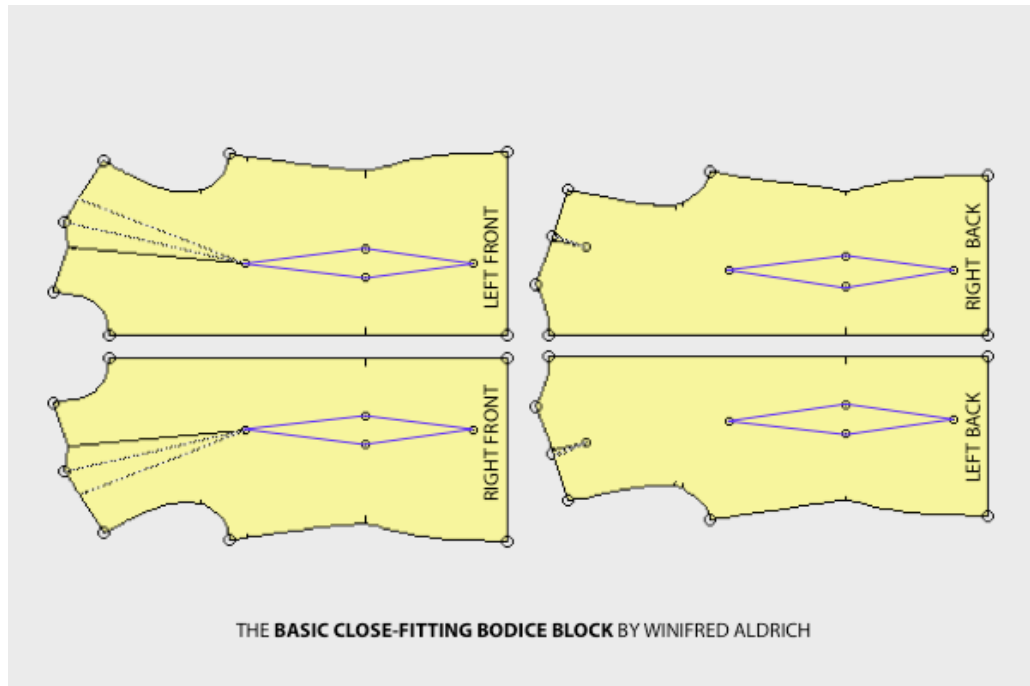


Figure 8.1. The original close-fitting bodice (hip) block by W. Aldrich (1994:18-19,33)

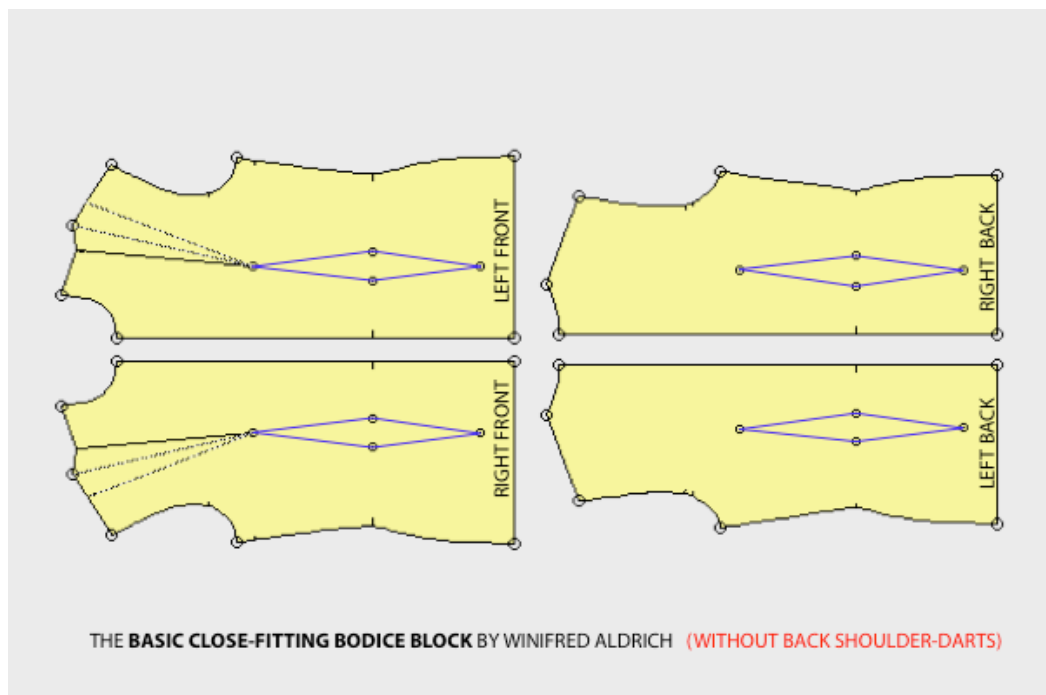


Figure 8.2. The original close-fitting bodice (hip) block by W. Aldrich (1994:18-19,33), after having eliminated the back mid-shoulder darts on both sides

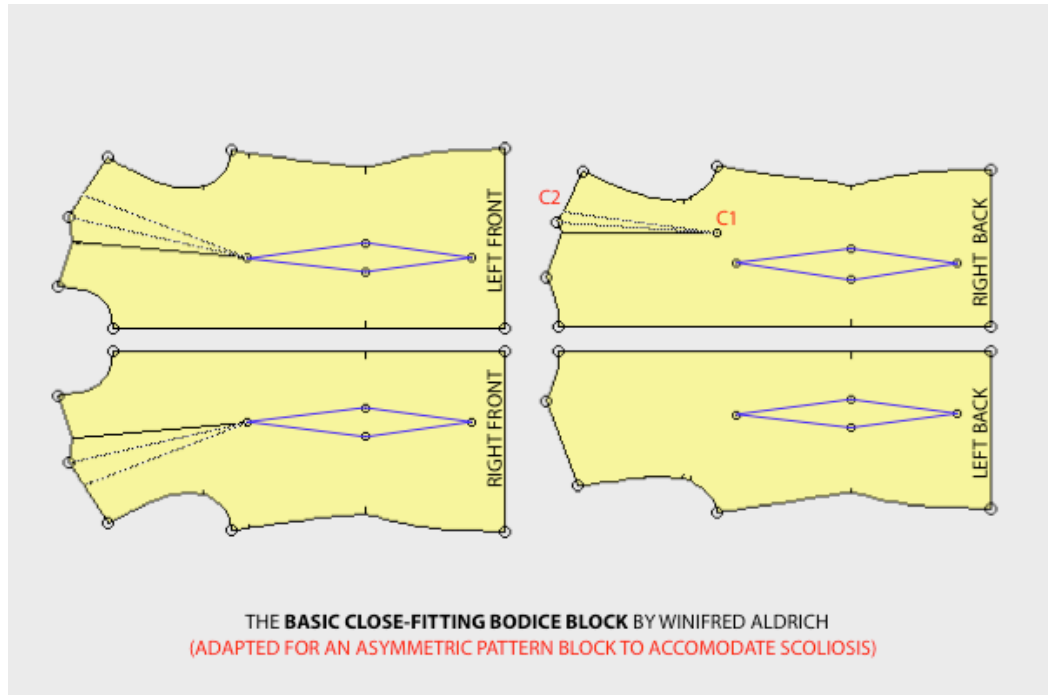


Figure 8.3. The close-fitting bodice (hip) block (originated by W. Aldrich, 1994:18-19,33) with a mid-shoulder dart, on the right back pattern, only, starting at Landmark C1 (peak of the curvature) and ending at Landmark C2 (vertically up on the shoulder-line), adapted to provide the extra fabric needed for the prominent part, in order to accommodate the curvature due to scoliosis

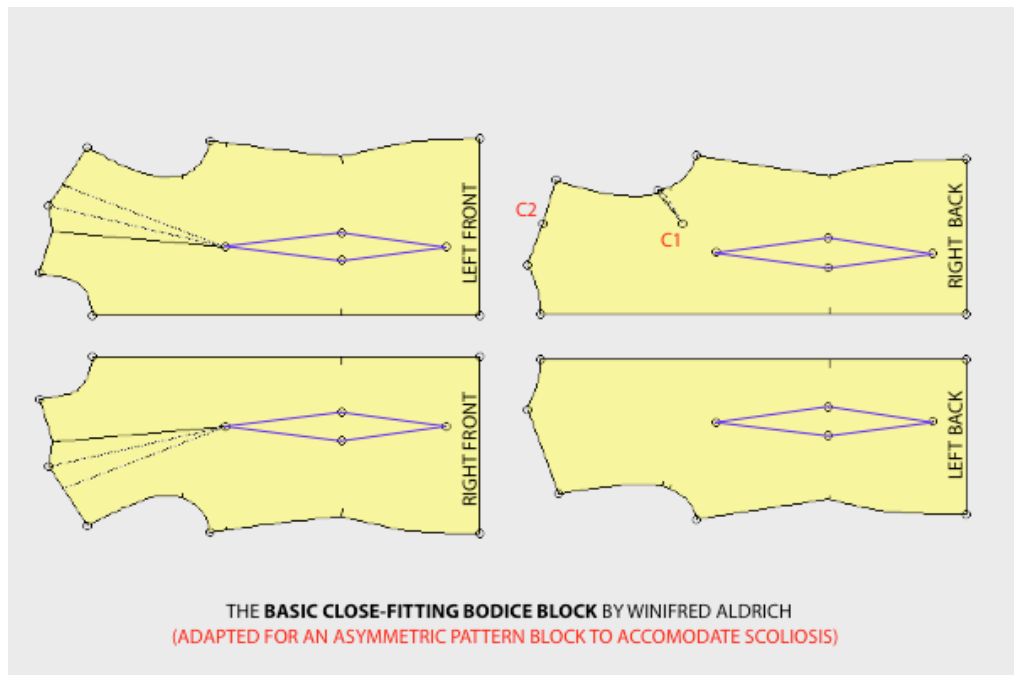


Figure 8.4. The close-fitting bodice (hip) block (originated by W. Aldrich, 1994:18-19,33) when the right back shoulder dart, starting at C1, is manipulated and transferred, by 100%, to the right back mid-scy (RMidB), on the scoliotic curve's side, for a better shaping and a more aesthetically pleasing result

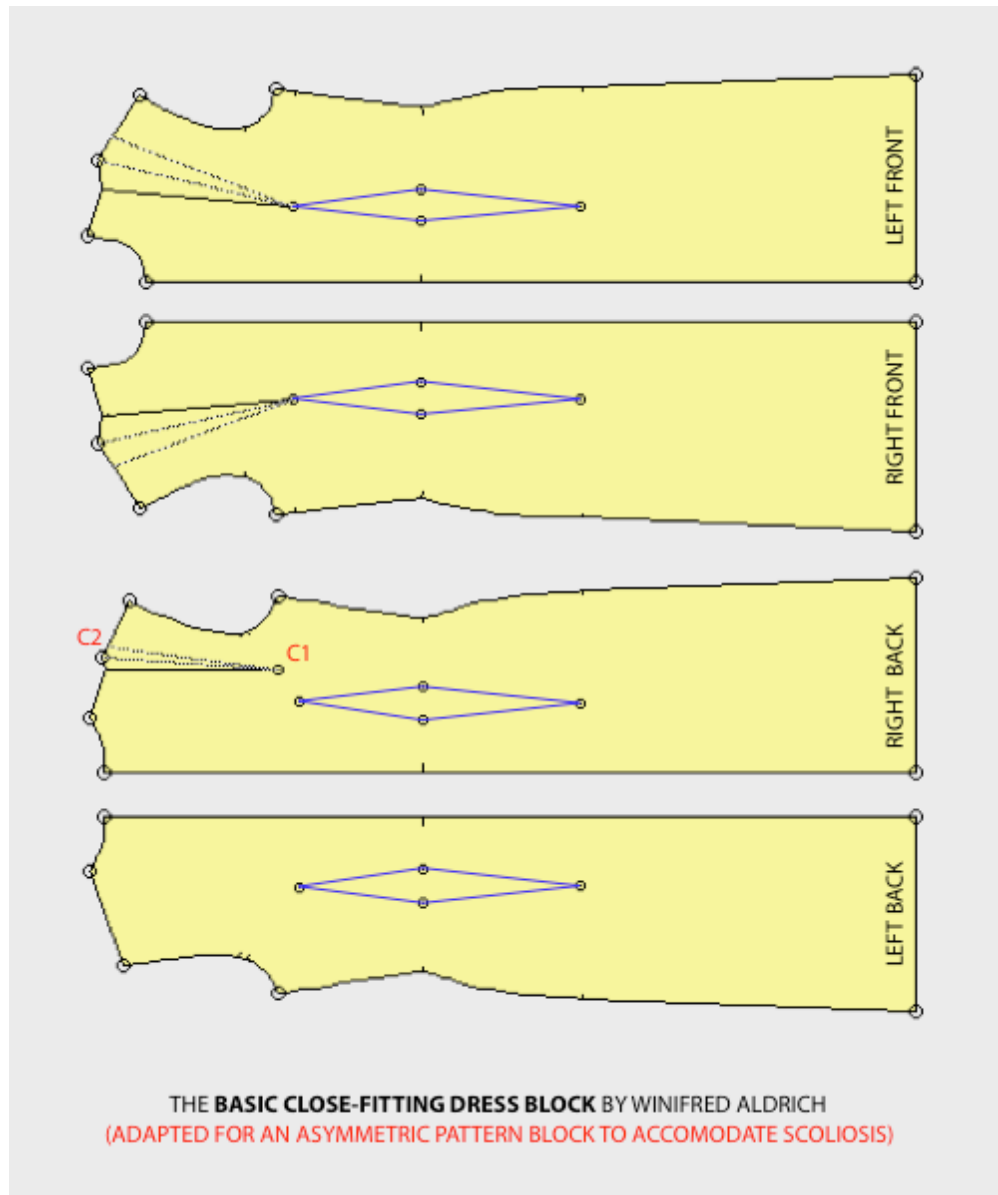


Figure 8.5. The adapted close-fitting one-piece basic dress block (originated by Aldrich, 1994:18-19, 33-34) with a mid-shoulder dart, on the right back pattern, only, starting at Landmark C1 (peak of the curvature) and ending at Landmark C2 (vertically up on the shoulder-line), adapted to provide the extra fabric needed for the prominent part, in order to accommodate the curvature due to scoliosis

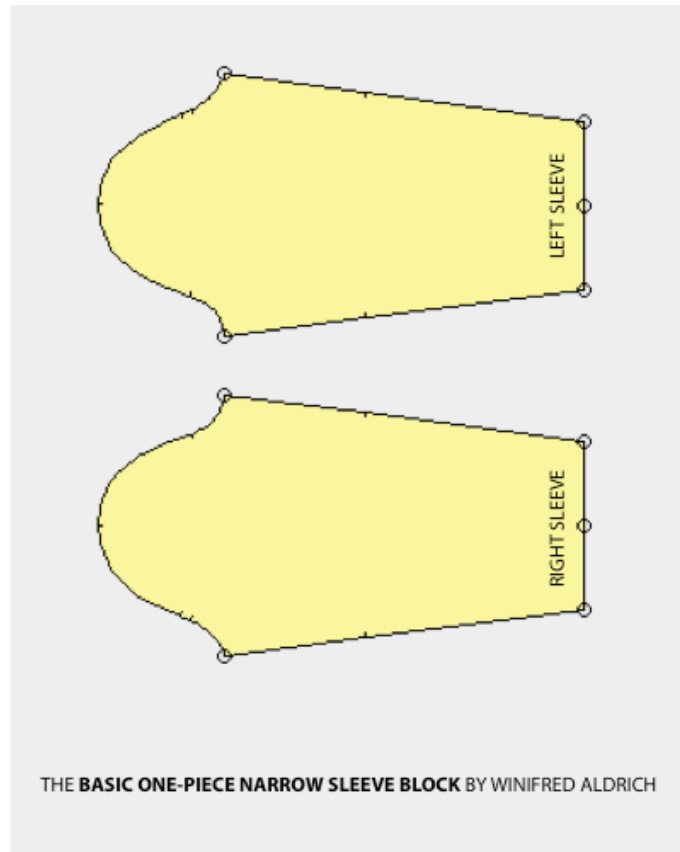


Figure 8.6. The one-piece narrow sleeve block (Aldrich, 1994:26-27)

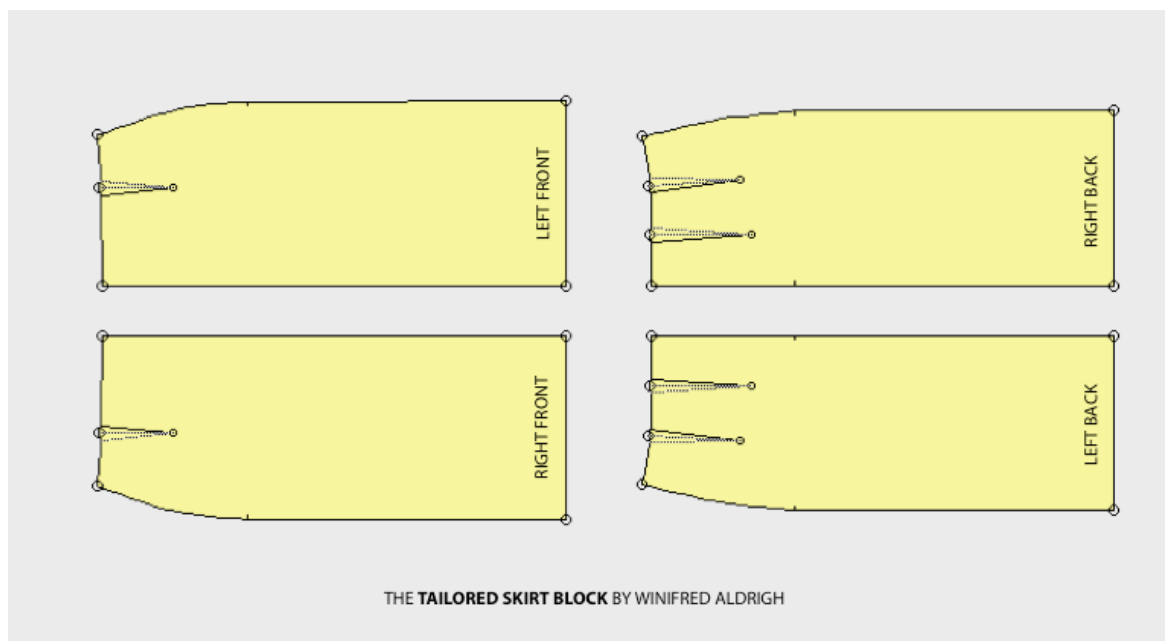


Figure 8.7. The tailored skirt block by W. Aldrich (1994:56-57)

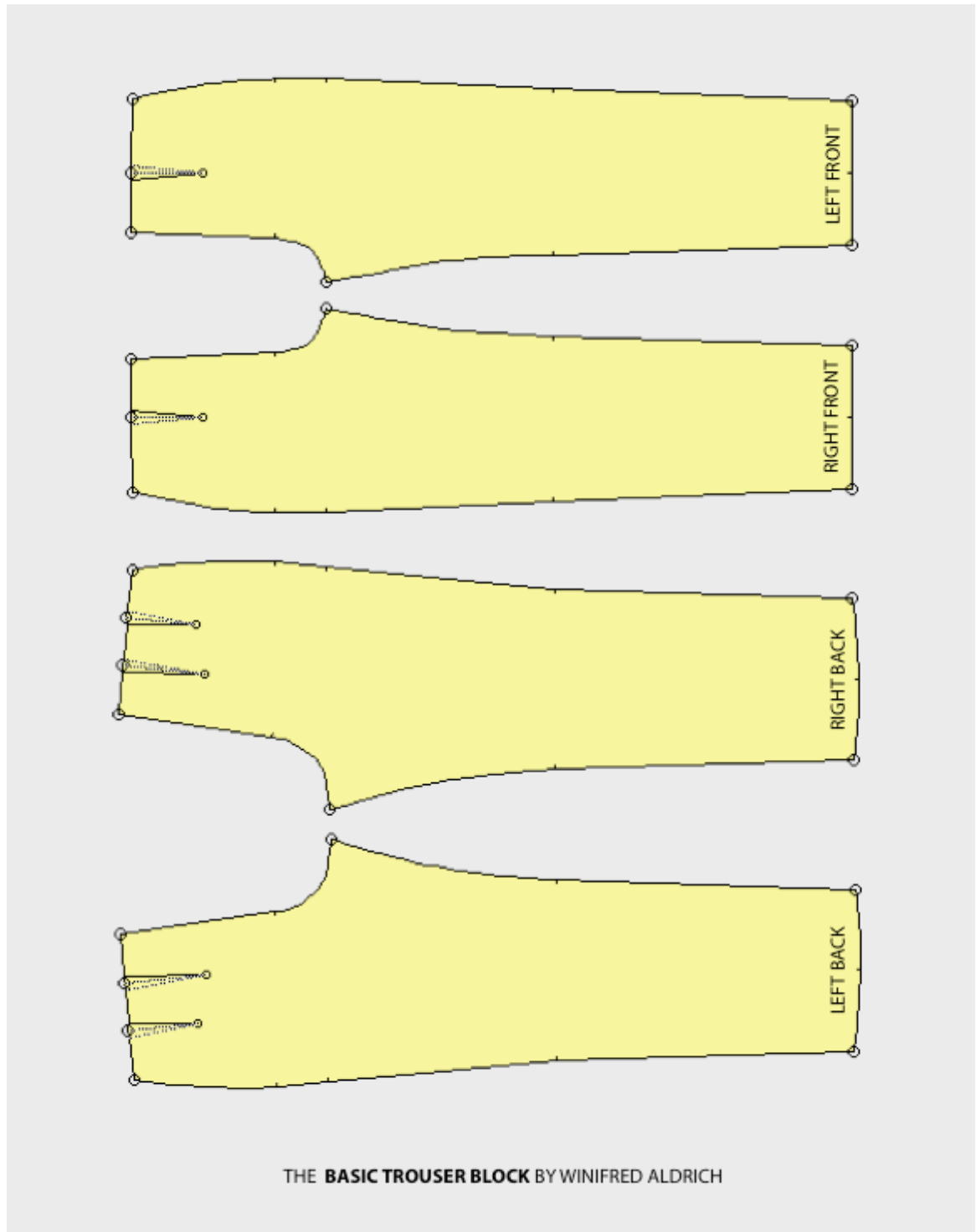


Figure 8.8. The basic trouser block by W. Aldrich (1994:76-77)

8.3. Drafting the Basic ‘Blocks’

According to Gill (2011), pattern construction occurs in a 2D Cartesian coordinate system, guided by body dimensions and ease. This can be modelled in the form of an *algorithm* relating to the placement of *cardinal points* defining the pattern outline (Gills, 2011: 228-241), while garments are generally altered at these *cardinal* or *grade points* (Istook, 2002:63). Critical alteration points are usually related to the human girth measurements of the neck, bust, waist, hips, etc.

Hence, *cardinal points* are used to describe the pattern construction of the basic blocks used in this research project, which were originated from Winifred Aldrich’s basic blocks.

At first, all the *vertices* of the basic pattern block outlines were numbered (Figures 8.9-8.13, below), in order to facilitate the pattern drafting procedure and to demonstrate how the patterns were developed, following specific grade rules (see Tables 8.2-8.6 – Appendix C). This would enable other researchers to replicate the process (Chapter 8.4.2, in conjunction with Appendix C) and be able to build on it, in order to conduct further research. It is crucial to understand that the *cardinal point numbers* were used to identify the location of a required action by the CAD system (*PolyPatternM2M* software), telling the system how to alter a pattern, i.e. how to increase or decrease in size, according to the grade rules created and applied to the pattern pieces.

The next step was to ensure that every numbered *cardinal point* or *vertex* was unique in each piece of a specific pattern style, while two pattern pieces belonging to the same block could have the same number of cardinal points or vertices (i.e. the left and right front bodice patterns have 17 cardinal points, each) (Figure 8.9).

The last step was to identify all the numbered vertices of each pattern piece that would be involved in the M2M alteration (grading) process. In general, all grade points needed

to be included in this process, apart from those that would be graded proportionately to others. For example, *vertex No 4* of the left front bodice block was omitted from the alteration rules' list (see Table 8.2 - Appendix C), since it did not need to be graded specifically; it was graded following proportional grading from *vertex No 3* to *vertex No 5* (Figure 8.9). Moreover, custom-made patterns for women with significant fit problems or with non-standard body configurations might need additional alteration rules. For example, *vertex No 14* of the right back bodice block required an additional rule that was not used for the left back bodice block, as there was no equivalent vertex on that pattern piece (see Figure 8.9 and Table 8.2 – Appendix C).

Figures 8.9 & 8.10, below, show the numbered basic blocks - with the final adaptations - for the bodice and the dress, while Figures 8.11-8.13 show the original numbered basic blocks for the sleeve, skirt and trousers, respectively.

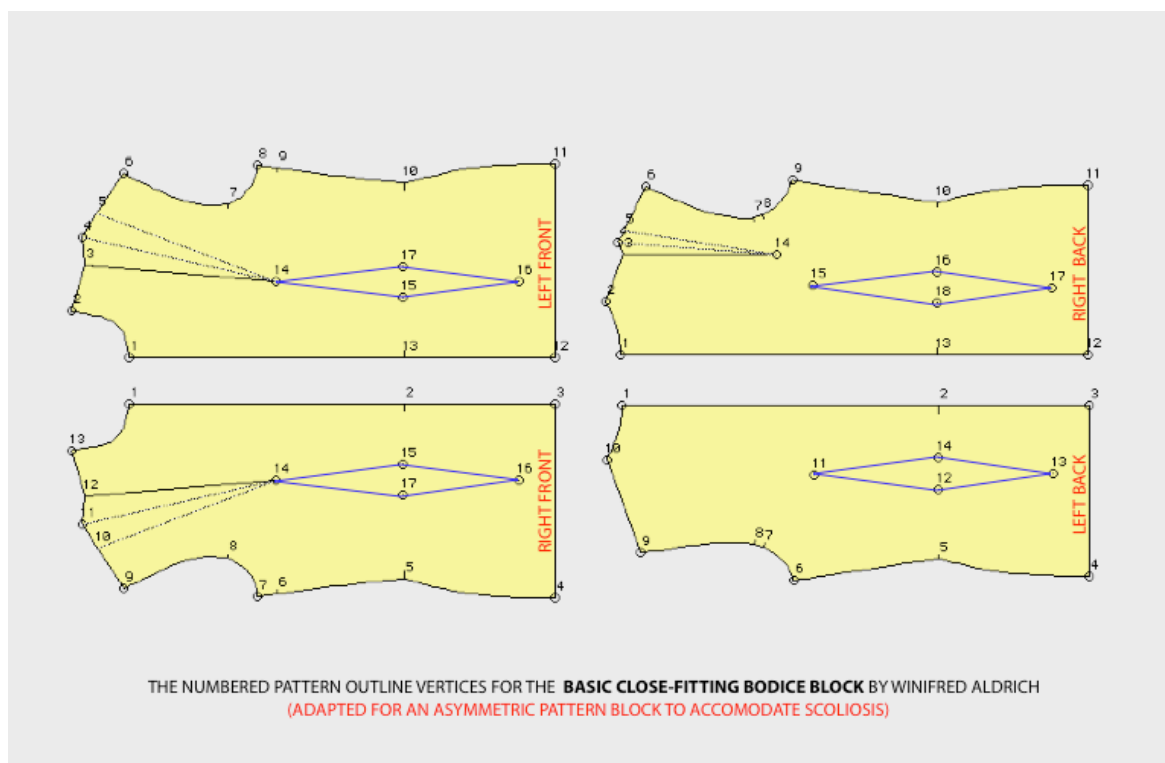


Figure 8.9. The numbered pattern outlines for the close-fitting bodice (hip) block (originated by W. Aldrich, 1994:18-19,33)

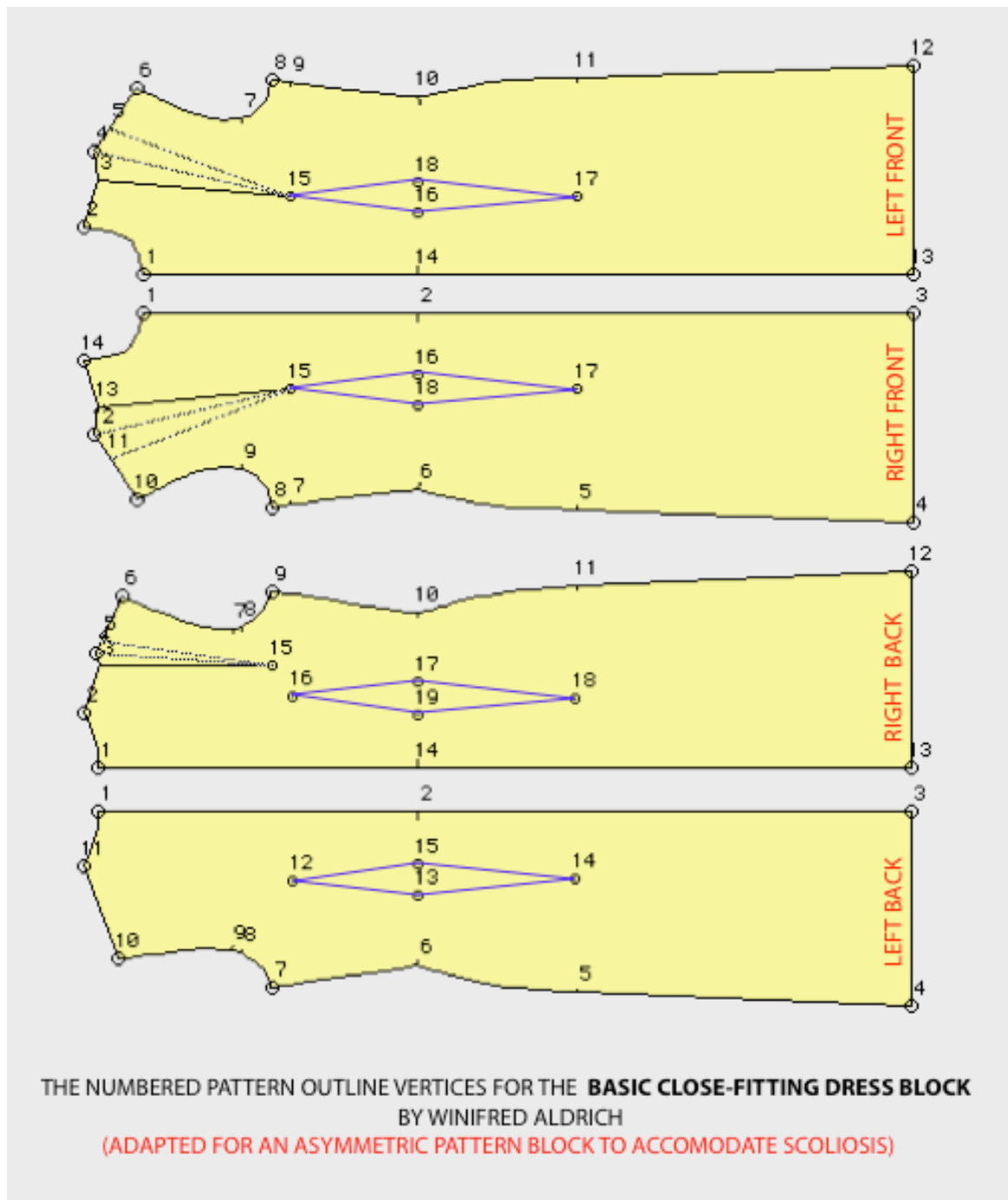


Figure 8.10. The numbered pattern outlines for the one-piece close-fitting dress block (originated by W. Aldrich, 1994:18-19,33-34)

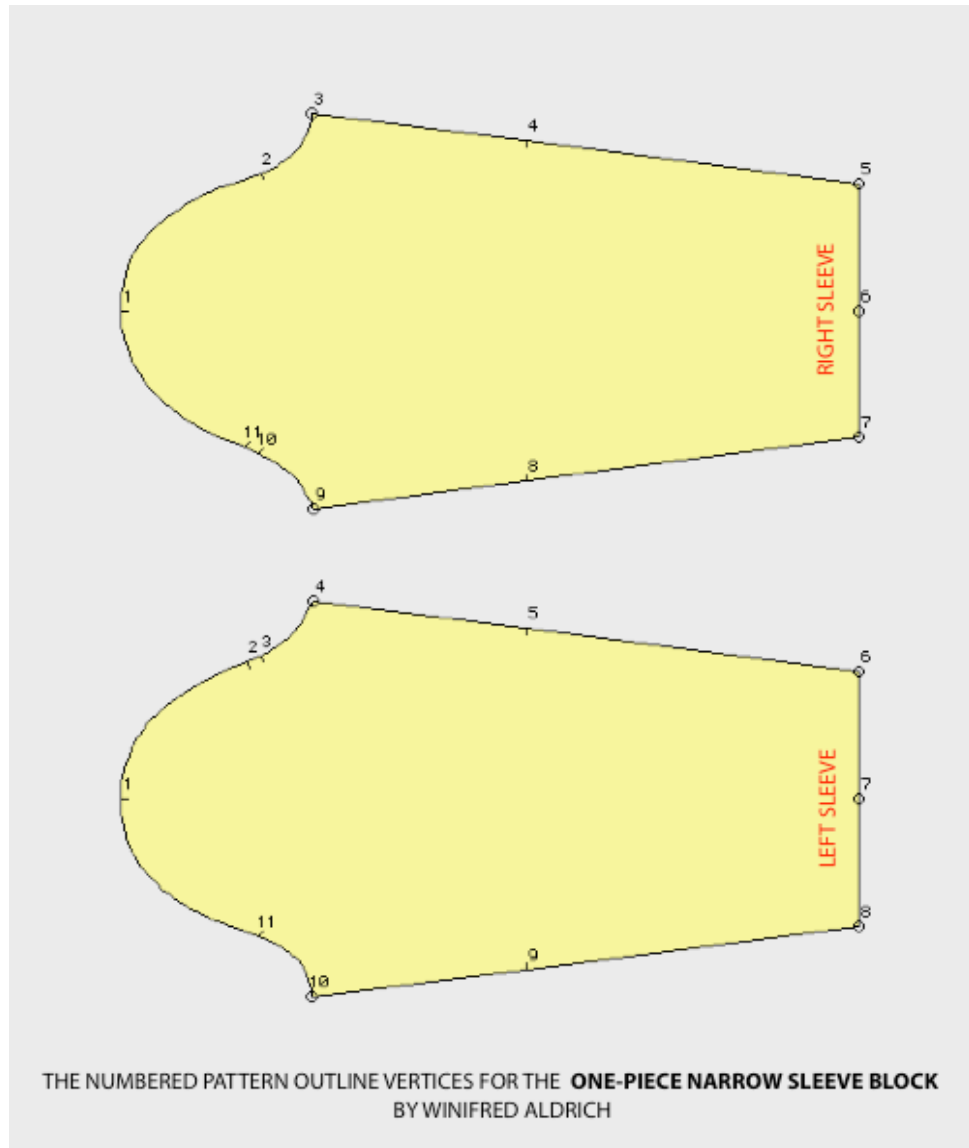


Figure 8.11. The numbered pattern outlines for the one-piece narrow sleeve block (originated by W. Aldrich, 1994:26-27)

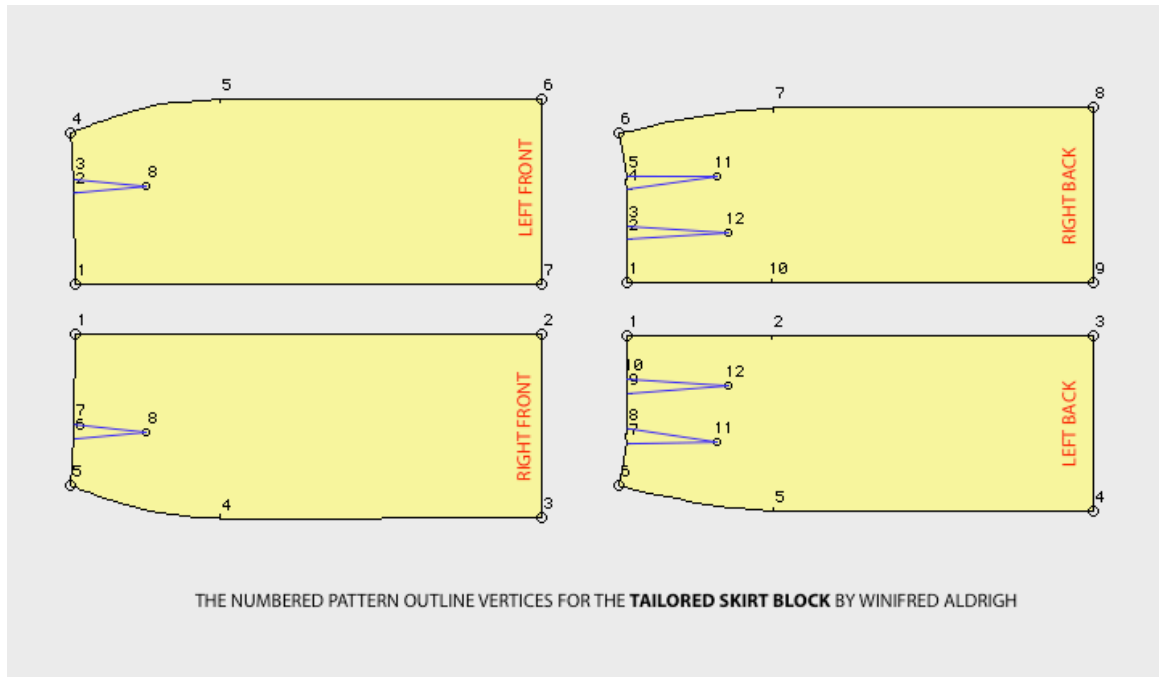


Figure 8.12. The numbered pattern outlines for the tailored skirt block (originated by W. Aldrich, 1994:56-57)

Overall, after the patterns pieces for each style were numbered, each scoliotic group's median body measurements, for 36 (populated) out of 180 groups, were input in the *PolyPattern-M2M* database, in order to create automated custom basic patterns of four different garment styles, for each scoliotic group.

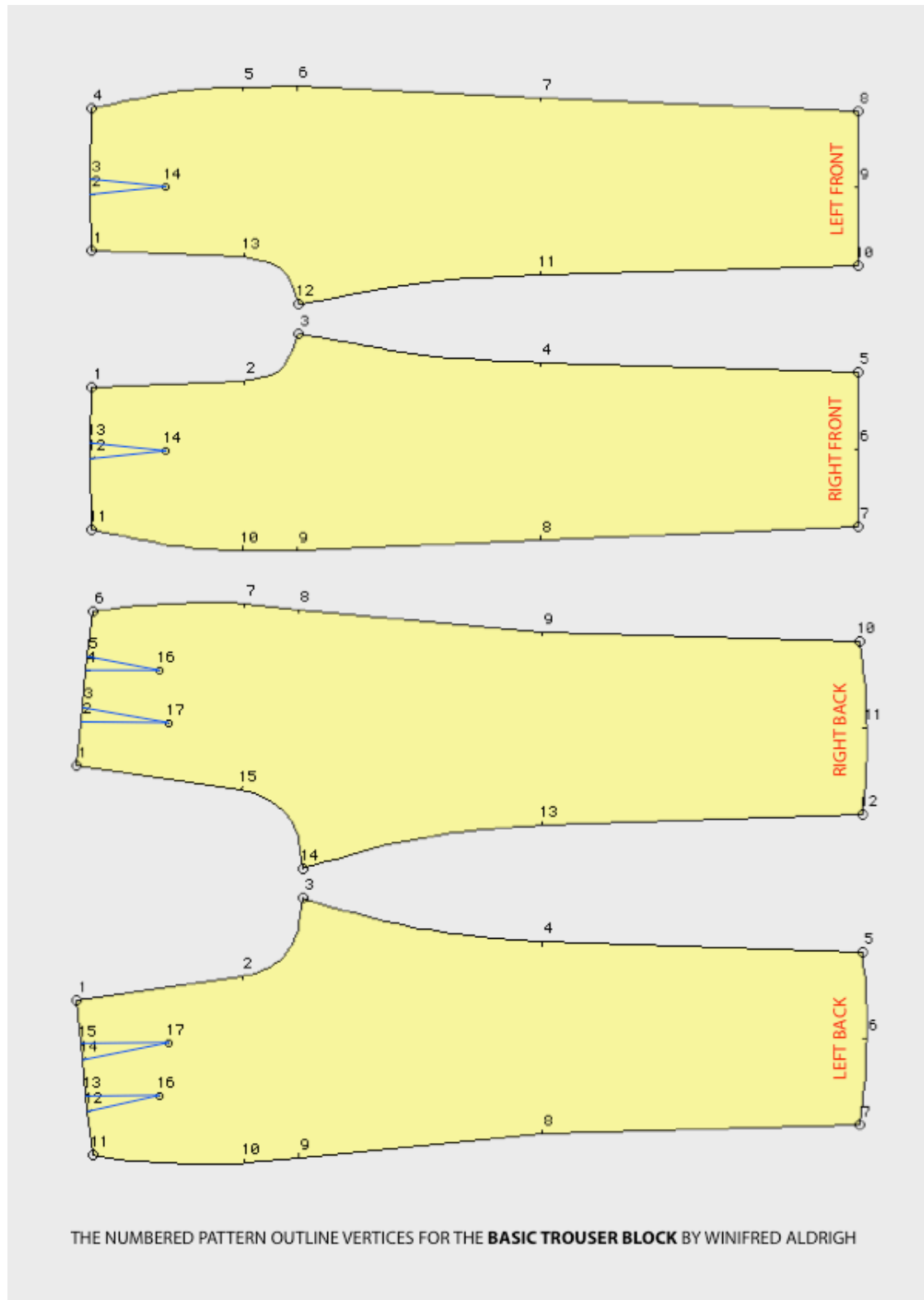


Figure 8.13. The numbered pattern outlines for the basic trouser block (originated by W. Aldrich, 1994:76-77)

8.4. Pattern CAD Systems

8.4.1. Pattern Design Software

As apparel manufacturers, today, need to supply an increasing number and variety of products at a faster rate throughout the year, having increased the pressure on the product development team - a key component of which are the *pattern making* and *cutting* departments - it is becoming essential to streamline these processes so that when the samples are completed and sent for approvals or merchandising, the pattern data itself is ready for production. Thus, the most efficient way for a designer or a clothing company to accomplish this is to construct their patterns directly in a CAD system.

THE *PolyPattern-Design* SOFTWARE¹¹⁰

The *PolyPattern-Design* software was used for drafting the basic pattern blocks, in this research, owing to the fact that I already possessed this software, having produced hundreds of correct patterns, throughout my 17-year career as a pattern designer. This particular software offers thoughtfully designed tools and advanced features, which ensure that the designer produces patterns with efficiency, ease and precision, while its unique '*snaps*' and keyboard input allow the designer to make patterns with greater speed, accuracy and control, no matter what pattern construction method they use. Moreover, it was the pattern-design software tested throughout the case study comparison on body measuring methods, resulting in accurately designed patterns (see Chapter 6.5).

'*PolyPattern-Design*' runs under both *MacOS* and *Windows* operating systems and can exchange data with other CAD systems via the international standards AAMA and

ASTM. Moreover, '*PolyPattern-Design*' reads native format data from *Lectra*, *Investronica* and *Gerber*, and communicates with most plotters, digitizers, cutters, databases, spreadsheets, and software applications.

8.4.2. Automated Custom Pattern Design Software

Today, production requirements including automated CAD patternmaking and marker making, single-ply cutting and short cycle production, are being embraced by a growing number of apparel companies (i.e. *Brooks' Brothers*, *Lands' End*, *Bodometrics*, etc.) that recognize the potential benefits of offering custom-fitted garments (Ashdown & Dunne, 2006:122). According to Istook (2002), almost every CAD system used in apparel patternmaking has created some kind of interface that would enable mass customisation through automatic alteration of patterns, based on individual measurements, while methods of creating automated custom patterns can be of two types (Istook, 2002:61-76). *Accumark MtM of Gerber*, *FitNet of Lectra* or *Intailor of Assyst Bullmer* belong to the first type, in which programs select the base size from the graded pattern set by comparing a primary body measurement of the individual with the body size chart and calculate the measurement differences at identified critical fit locations, applying changes to the chosen base pattern according to alteration rules based on these measurement differences, of the individual from the standard body measurements (Song & Ashdown, 2012:316). *Modulate of Optitex*, on the other hand, belongs to the second type, in which programs parametrically change a base pattern according to a set of defined dimensions, without requiring the development of a body size table or alteration rules; instead it is necessary to define a set of dimensions for a specific garment style, while the system shapes the garment to fit these dimensions, generating a custom pattern (Song & Ashdown, 2012:316; Istook, 2002:61-76).

¹¹⁰ <http://www.polytropon.com/en/PolyPattern/cad-pattern-design-software.html> (Accessed 6th March

Nevertheless, as Apeagyei and Otieno (2007:349-365) have found, commercial custom CAD software can manipulate standard-type garments with basic features but not in complicated styles, such as asymmetric designs. Ashdown and Dunne (2006:121-136), after exploring issues in setting up a custom apparel patternmaking process using 3D body scanning and CAD software, have found that the success rate was still low (70%), even after three iterative corrections of all elements (i.e. reliability of measurement data, system variables, individual fit preferences, etc). In addition, one of the most important technical obstacles that apparel companies have to overcome, in order to implement an accurate custom fit system, involves the research and development of system variables to link pattern changes to body measurements and define desired ease amounts (Ashdown & Dunne, 2006:121-136; Istook, 2002:61-76). Overall, research on whether consumers would be comfortable with the 3D body scanning process, expending the necessary time and money for this service, along with the issue of individual fit preferences that further complicate the custom fit process, should be addressed by manufacturers, developing ways of communicating and providing the preferred fit to produce garments that satisfy their consumers (Ashdown & Dunne, 2006:122).

THE '*PolyPatternM2M*' SOFTWARE¹¹¹

PolyPattern software is a well-known CAD system for pattern making and marker production, while its made-to-measure module, *PolyPatternM2M*, combines both mentioned methods of creating automated custom patterns, allowing the user to specify body measurements for a particular individual. Since the garment styles selected for this research were all basic styles, I determined - after having tested on myself, garments based on patterns extracted directly from this software that were derived from my own

2013)

¹¹¹ <http://polytropon.com/en/index.html> (Accessed 24th May 2012)

body measurements - that the *PolyPatternM2M* software was more than appropriate for this study.

According to the *PolyPatternM2M* method, the user selects the base size pattern from their database, not previously requiring the development of a body size table or a graded pattern set. Then, the program calculates the measurement differences at identified critical fit locations and applies changes to the base pattern, according to *alteration rules*, based on the measurement differences of the individual from the *base* pattern. These *critical fit points* are mapped to the patterns, as numbered vertices (Figures 8.9 – 8.13) via a set of *grade* or *alteration rules* (algorithms) for each pattern style (see Tables 8.2-8.6 - Appendix C). Once all the grade rules for each garment style, are determined by the pattern designer describing point number, direction of the point's movement and amount of movement by a *mathematical formula* (grade rule), the information needs to be entered into the M2M automated system. The list of such formulas for each cardinal point, defined by number and x and y coordinates, form the *Style Rules* for each garment style (see Tables 8.2-8.6 – Appendix C).

Given the *base pattern* for a certain style, the rules for that style, and a specific individual's body measurements, *PolyPatternM2M* is able to generate the patterns for that style for the specific individual.

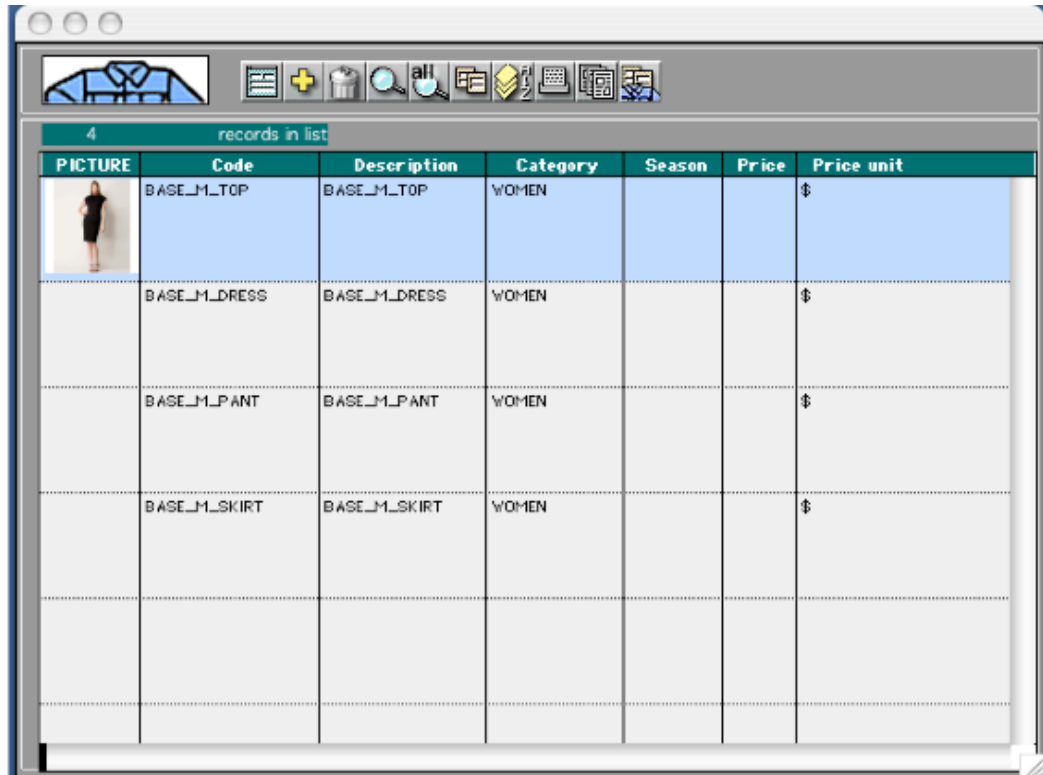
The important aspect of the '*PolyPatternM2M*' solution is a database, which stores and relates '*style*' (i.e. *basic bodice block*) (Figure 8.14) and '*client*' (i.e. *subject with scoliosis No 25*) information (Figure 8.15). The only requirements needed for this software application are a set of basic pattern blocks called '*the base set*' (i.e. the UK size 12 basic bodice block, by W. Aldrich, generated via '*PolyPattern-Design*') (Figure 8.16) and the accurate body measurements of that specific body, for which *the base set* was made to fit, taken from a standard body size chart (Aldrich, 1994:15) (Figure 8.17).

In Figure 8.17 the fourth column represents the accurate body measurements of the specific body that *the base set* was made to fit (body measurements for UK size 12), while the fifth column represents *Subject 25's* body measurements.

Thus, *the UK size 12 set of basic pattern blocks*, originated by W. Aldrich and generated via W. Aldrich's body measurement charts (Aldrich, 1994:15), were used as '*the base set*' in the *PolyPatternM2M* automated made-to-measure system, in order to create asymmetric basic pattern blocks to accommodate scoliosis, introducing two adapted basic pattern styles (bodice and dress) for this study, and two original industry basic pattern styles (skirt and trousers):

- **The asymmetric basic close-fitting bodice block with one-piece narrow sleeves**, originated by Winifred Aldrich (1994: 18,19,33,26,27) (Figures 8.9 & 8.11)
- **The asymmetric basic close-fitting one-piece dress block with one-piece narrow sleeves**, originated by Winifred Aldrich (1994: 18,19,33,34,26,27) (Figures 8.10 & 8.11)
- **The tailored skirt block**, originated by Winifred Aldrich (1994: 56,57) (Figures 8.12)
- **The basic trouser block** by Winifred Aldrich (1994: 76,77) (Figures 8.13)

Once a *style* has been defined and a *subject* has been measured, all the vertices of each basic pattern block are indicated with numbers via the option 'View – Show point numbers' on the *PolyPattern-Design* software toolbar (i.e. numbers 1-17 show all the vertices of the left front basic bodice block) (Figure 8.18).



4 records in list


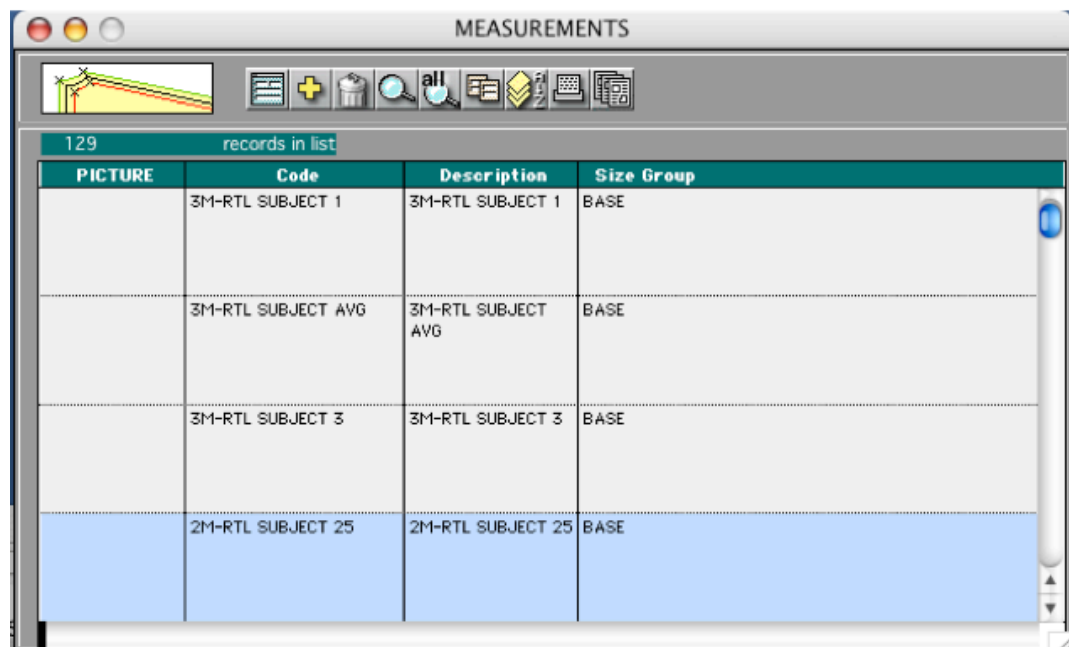
PICTURE	Code	Description	Category	Season	Price	Price unit
	BASE_M_TOP	BASE_M_TOP	WOMEN			\$
	BASE_M_DRESS	BASE_M_DRESS	WOMEN			\$
	BASE_M_PANT	BASE_M_PANT	WOMEN			\$
	BASE_M_SKIRT	BASE_M_SKIRT	WOMEN			\$

Figure 8.14. The *PolyPatternM2M* 'style database'



MEASUREMENTS

129 records in list

PICTURE	Code	Description	Size Group
	3M-RTL SUBJECT 1	3M-RTL SUBJECT 1	BASE
	3M-RTL SUBJECT AVG	3M-RTL SUBJECT AVG	BASE
	3M-RTL SUBJECT 3	3M-RTL SUBJECT 3	BASE
	2M-RTL SUBJECT 25	2M-RTL SUBJECT 25	BASE

Figure 8.15. The *PolyPatternM2M* 'subject database'

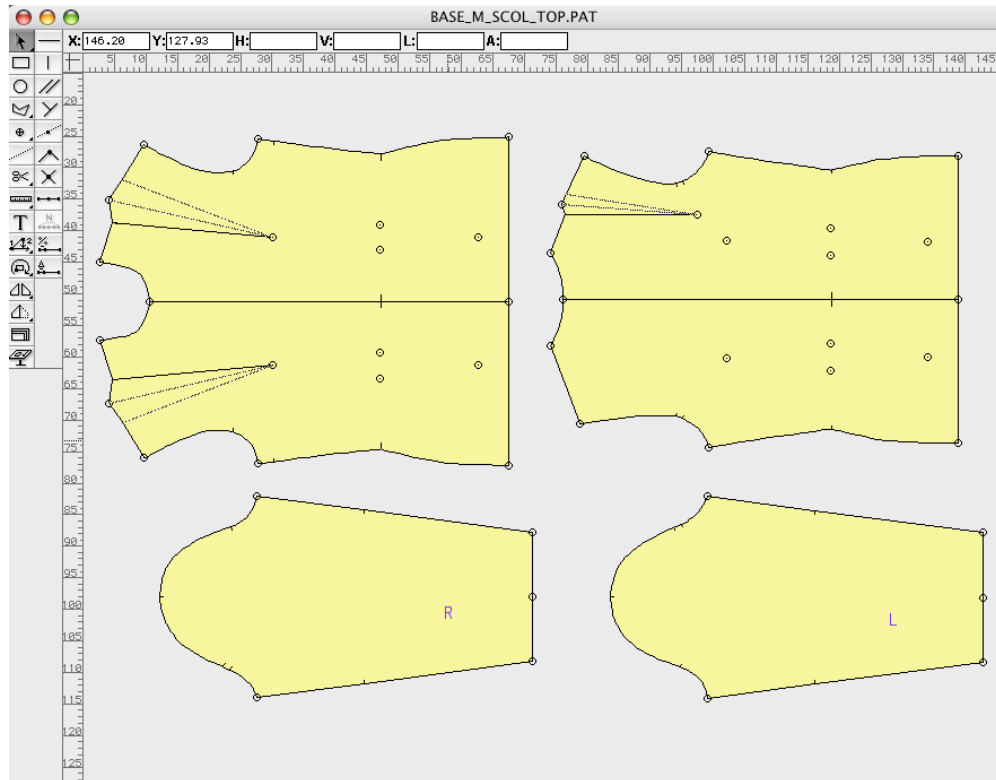


Figure 8.16. *The base set* (i.e. the UK size 12 basic bodice block, by W. Aldrich, generated via PolyPattern-Design

MEASUREMENTS				
Code: 2M-RTL SUBJECT 25		Description: 2M-RTL SUBJECT 25		
Size group: BASE		Notes:		
Basic size: BASE		Curve Size 2 - Right S Thoraco-lumbar (SUBJECT 25) - M		
Label	Dimension	Tol.	BASE	M2M
1	HEIGHT	± 0.00	163.00	166.00
2A	DRESS LENGTH TO KNEE L	± 0.00	98.00	97.50
2B	DRESS LENGTH TO KNEE R	± 0.00	98.00	98.50
3A	FULL BODICE LENGTH FL	± 0.00	42.00	41.00
3B	FULL BODICE LENGTH FR	± 0.00	42.00	41.50
3C	FULL BODICE LENGTH BL	± 0.00	43.00	39.50
3D	FULL BODICE LENGTH BR	± 0.00	43.00	40.00
4A	STRAP FRONT L	± 0.00	26.25	22.00
4B	STRAP FRONT R	± 0.00	26.25	23.00
5A	BUST POINT HEIGHT L	± 0.00	17.00	18.50
5B	BUST POINT HEIGHT R	± 0.00	17.00	19.00
6A	BUST RADIUS L	± 0.00	8.00	8.50
6B	BUST RADIUS R	± 0.00	8.00	8.00
7	CENTRE FRONT BODICE	± 0.00	38.00	31.50
8A	NAPE TO BUST POINT L	± 0.00	34.00	33.50
8B	NAPE TO BUST POINT R	± 0.00	34.00	32.00
9A	NAPE TO WAIST FRONT L	± 0.00	52.00	51.00
9B	NAPE TO WAIST FRONT R	± 0.00	52.00	51.50
10	CHEST WIDTH	± 0.00	32.50	34.00
10A	HALF ACROSS CHEST L	± 0.00	16.25	16.50
10B	HALF ACROSS CHEST R	± 0.00	16.25	17.50
11	HIGH BUST CIRCUMFERENCE	± 0.00	84.00	84.00

Figure 8.17. The accurate body measurements of that specific body for which '*the base set*' was made to fit, taken from a standard body size chart (Aldrich, 1994:15)

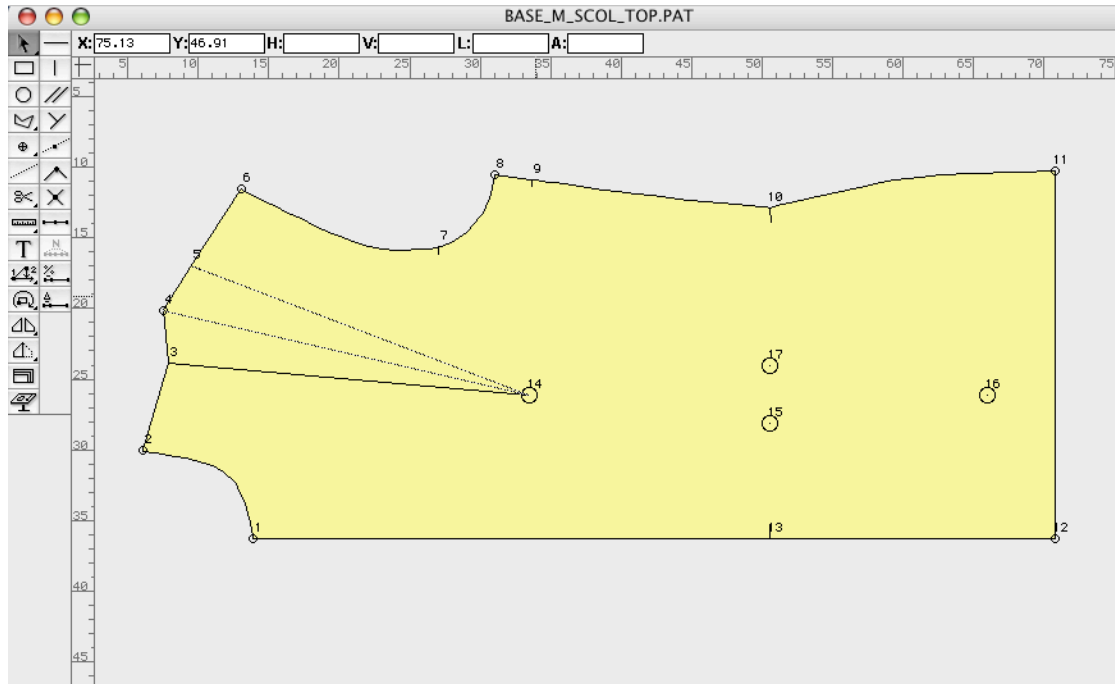


Figure 8.18. 17 numbered vertices illustrate the left front basic bodice block's pattern outline

These numbered vertices are needed, in order to create the *grade rules* (the set of algorithm formulas defining each vertex) for each *style*, using x and y coordinates for each vertex, connecting each alteration grade to a body measurement - i.e. the y coordinate of vertex no 2 – left neck point -- of the front left bodice block equals the 1/5 of the Neck Base Circumference (Figure 8.19):

$$02yFrontLeft [Equals] 1/5 Neck Base Girth [Multiplied by] (-1)$$

The x and y coordinates in the 'Polypattern-M2M' Software have positive values when moving to the right and downwards, respectively, and negative values when moving to the left and upwards, respectively. Hence, the negative value (-1) in the above formula indicates that *Subject 25's* left neck point (2) should move upwards, her neck being larger than a UK size 12 neck base measurement (40cm > 37cm).

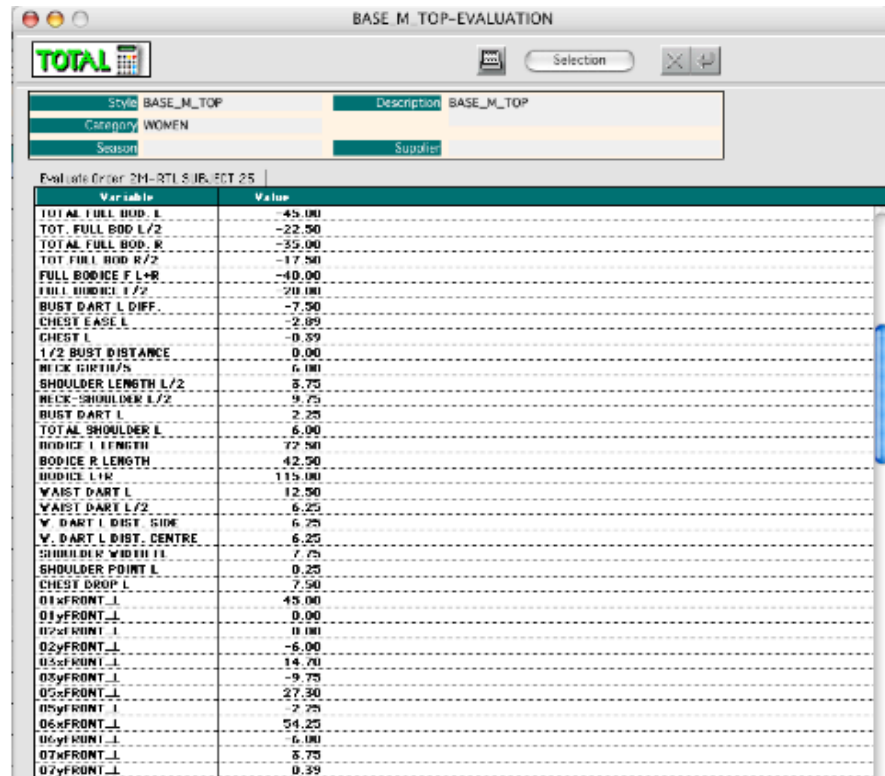
Overall, once the *grade (alteration) rules* have been defined for each *style*, then the *style rules* are being created for each *subject* (Figure 8.20). Every alteration rule should be checked for accuracy before it is implemented. After check is completed for each rule on its own, combinations of rules are tested. When all rules have been tested using a variety of different measurements (on the same location) and combinations, the user can be sure that the grade rules are created accurately, at least for the specific individual, resulting in correctly fitting patterns.

Variable	Operand1	Constant1	Operator	Operand2	Constant2
TOTAL FULL BOD. L	FULL BODICE LENGTH FL	0	+	FULL BODICE LENGTH BL	0.00
TOT. FULL BOD. L/2	TOTAL FULL BOD. L	0	*	Number	0.50
TOTAL FULL BOD. R	FULL BODICE LENGTH FR	0	+	FULL BODICE LENGTH BR	0.00
TOT. FULL BOD. R/2	TOTAL FULL BOD. R	0	*	Number	0.50
FULL BODICE F L+R	TOT. FULL BOD. L/2	0	+	TOT. FULL BOD. R/2	0.00
FULL BODICE F/2	FULL BODICE F L+R	0	*	Number	0.50
BUST DART L DIFF.	FULL BUST WIDTH FL	0	-	HALF ACROSS CHEST L	0.00
CHEST EASE L	BUST DART L DIFF.	0	+	Number	0.30
CHEST L	HALF ACROSS CHEST L	0	+	CHEST EASE L	0.00
1/2 BUST DISTANCE	BUST P TO BUST P	0	*	Number	0.50
NECK GIRTH/5	NECK BASE GIRTH	0	*	Number	0.20
SHOULDER LENGTH L/2	SHOULDER LENGTH L	0	*	Number	0.50
NECK-SHOULDER L/2	NECK GIRTH/5	0	+	SHOULDER LENGTH L/2	0.00
BUST DART L	BUST DART L DIFF	0	+	NECK-SHOULDER L/2	0.00
TOTAL SHOULDER L	BUST DART L	0	+	SHOULDER LENGTH L/2	0.00
BODICE L LENGTH	TOT. FULL BOD. L/2	0	+	HP DEPTH L	0.00
BODICE R LENGTH	TOT. FULL BOD. R/2	0	+	HP DEPTH R	0.00
BODICE L+R	BODICE L LENGTH	0	+	BODICE R LENGTH	0.00
WAIST DART L	HP WIDTH FL	0	-	WAIST WIDTH FL	0.00
WAIST DART L/2	WAIST DART L	0	*	Number	0.50
W. DART L DIST. SIDE	WAIST DART L/2	0	+	1/2 BUST DISTANCE	0.00
W. DART L DIST. CENTRE	WAIST DART L/2	0	+	1/2 BUST DISTANCE	0.00
SHOULDER WIDTH FL	SHOULDER TIP WIDTH FL	0	-	NECK GIRTH/5	0.00
SHOULDER POINT L	SHOULDER WIDTH FL	0	+	BUST DART L DIFF	0.00
CHEST DROP L	TOT. FULL BOD. L/2	0	-	SIDE SEAM LENGTH TO WAIST L	0.00
D1xFRONT_L	FULL BODICE F/2	0	-	CENTRE FRONT BODICE	0.00
D2xFRONT_L		0	*	Number	0.00
D3xFRONT_L	NECK GIRTH/5	0	*	Number	-1.00
D4xFRONT_L	HEIGHT OF SHOULDER SLOPE L	0	*	Number	0.42
D5xFRONT_L	NECK-SHOULDER L/2	0	*	Number	-1.00

Figure 8.19. The list of x and y coordinates, for each vertex, of each pattern, of each garment style, that form the *grade rules* for each garment style in *PolyPatternM2M*

Hence, with the press of a few buttons, an order is processed and the *automated made-to-measure* pattern blocks for the specific '*subject*' and '*style*' are generated (i.e. 'Bodice Pattern Block' for Subject 25) (Figure 8.21).

The only limitation in the use of the *PolyPatternM2M* software is that patterns for all sizes incorporate the same amount of ease, as defined for the *base set* (**UK size 12** originated by W. Aldrich), indicating that the *software's* grading system is not (yet) able to produce patterns with extra ease for larger sizes, if needed.



Variable	Value
TOTAL FULL BOD. L	45.00
TOT. FULL BOD. L/2	22.50
TOTAL FULL BOD. R	35.00
TOT FULL BOD R/2	17.50
FULL BODICE F L+R	-40.00
FULL BODICE L/2	20.00
BUST DART L DIFF.	-7.50
CHEST EASE L	-2.89
CHEST L	-0.39
1/2 BUST DISTANCE	0.00
NECK GIRTH/S	6.00
SHOULDER LENGTH L/2	8.75
NECK-SHOULDER L/2	9.75
BUST DART L	2.25
TOTAL SHOULDER L	6.00
INDICE L LENGTH	72.50
BODICE R LENGTH	42.50
INDICE L/R	115.00
WAIST DART L	12.50
WAIST DART L/2	6.25
W. DART L DIST. SIDE	6.25
W. DART L DIST. CENTRE	6.25
SHOULDER WIDTH L	7.75
SHOULDER POINT L	0.25
CHEST DROP L	7.50
01xFRONT L	45.00
01yFRONT L	0.00
02xFRONT L	0.00
02yFRONT L	-5.00
03xFRONT L	14.75
03yFRONT L	-9.75
05xFRONT L	27.30
05yFRONT L	2.25
06xFRONT L	54.25
06yFRONT L	6.00
07xFRONT L	8.75
07yFRONT L	0.39

Figure 8.20. A specific subject's *grade (alteration) rules'* measurement differences compared to the *base set's* measurements

Notwithstanding, the *PolyPatternM2M* proved to be a useful tool in designing accurate patterns for asymmetric bodies due to scoliosis. In using this software, I was able to generate and test a larger number of patterns over four different garment styles for 74 subjects, while it enabled a number of comparisons between patterns derived from individual measurements and patterns derived from different scoliotic groups' *median* measurements (see experimental studies in Chapter 9). It would have been very time-consuming and nearly impossible to develop each pattern block, individually, if they were designed manually.



Figure 8.21. The automated made-to-measure pattern blocks for the specific *subject* and *style*¹¹²

¹¹² The green-coloured pattern outline in the upper illustration (black-coloured pattern outline in the lower illustration) defines the automatically graded made-to-measure pattern, while the *base set's* pattern outline is defined with black colour

Chapter 9

Six Experimental Studies on Pattern Design and Grading

The sizing system adopted, relied on the design methodology employed for the development of the system. This was an iterative process, as each stage revealed new issues and concepts, while resulting in refinement and re-focus of the design based on the new information. Thus, given that all the measurements were taken with the aim of drafting original patterns from scratch, and not altering commercially-made patterns to fit women with scoliosis, a high degree of skill was necessary to create patterns from scratch, after measuring each subject in standing position.

The aim was to create a set of basic pattern blocks of 4 different basic styles (Chapter 8.4.2: 325), via ‘*PolyPattern-Design*’ and ‘*PolyPatternM2M*’ software¹¹³, based on the median body measurements for the most populated scoliotic groups (the **C₁₋₂₋₃R_{R-L}T_SS_{TL}** groups and the **C₁₋₂₋₃R_{R-L}T_CS_T** groups – Tables 7.20cdef and 7.19cd, *respectively* – Appendix B).

For this purpose, six experimental studies were conducted, in order to test and check the efficacy of the pattern blocks, in terms of design, construction and grading.

A key to describe the patterns, with the shortest possible acronym is included to the text (Table 9.2), for ease of reading, while Table 9.1 (Appendix C) forms the ‘*Subject Acronym Table*’.

¹¹³ <http://polytropon.com/en/index.html> (Accessed 24th May 2012)

Key to column headers for Table 9.1 (Appendix C)

Table 9.2

Subject	1 to 75 (<i>Subject 31 is excluded</i>)
Size	XS, S, M, L, XL
Garment	Bodice, Dress, Skirt, Trousers
C for Curve	1, 2, 3
R for Region	Left, Right
T for Type	S, C
S for Scoliosis	Cervical, Thoracic, Lumbar, Cervico-Thoracic, Thoraco-Lumbar, Cervico-Thoraco-Lumbar

Garment Pattern block derived from Median Measurements - Size XS	AVGXS
Garment Pattern block derived from Median Measurements - Size S	AVGS
Garment Pattern block derived from Median Measurements - Size M	AVGM
Garment Pattern block derived from Median Measurements - Size L	AVGL
Garment Pattern block derived from Median Measurements - Size XL	AVGXL

Thus, the Bodice pattern block for Subject 1, size Large, belonging to 'Curve size 3, Right, S-type, Thoraco-lumbar Scoliosis' Group becomes **S1L-Bodice-C₃R_RT_SS_{TL}** and the Skirt pattern block for Subject 71, size Medium, belonging to 'Curve size 2, Left, S-type, Thoraco-lumbar Scoliosis' Group becomes **S71M-Skirt-C₂R_LT_SS_{TL}**, while the Dress pattern block derived from the median measurements of i.e. the '**C₃R_RT_SS_{TL}**' group becomes **AVGM-Dress-C₃R_RT_SS_{TL}** (Table 9.1 – Appendix C), for size **M**.

Overall, Table 9.3 (Appendix C) describes all the measurements needed for designing the pattern blocks for the bodice, the dress, the skirt and the trousers, separately.

9.1. 1st Experimental Study

In order to check the '*PolyPatternM2M*' pattern blocks' accuracy, I attempted the **first experimental study** of this research that involved a pattern comparison (Figure 9.3) between a *bodice pattern block* constructed using pattern profiles, which I designed manually, using *PolyPatternDesign* CAD system (Figure 9.1), and a *bodice pattern block* constructed using pattern profiles derived directly (automatically) via *PolyPatternM2M* software (Figure 9.2). Both Bodice blocks were designed for *Subject 1* (**S1L-Bodice-C₃R_RT_SS_{TL}**), as it was the first subject measured for this research project.

It is evident from Figure 9.3 that the two basic Bodice pattern blocks for **S1L-Bodice-C₃R_RT_SS_{TL}** have very slight differences, mainly concerning front shoulder tip width, front left side width, both front and back hip widths and dart positioning, as well as both left and right sleeve crown heights.



Figure 9.1. **S1L-Bodice-C₃RRTS_{TL}** pattern block, designed manually in a CAD system called *PolyPatternDesign*

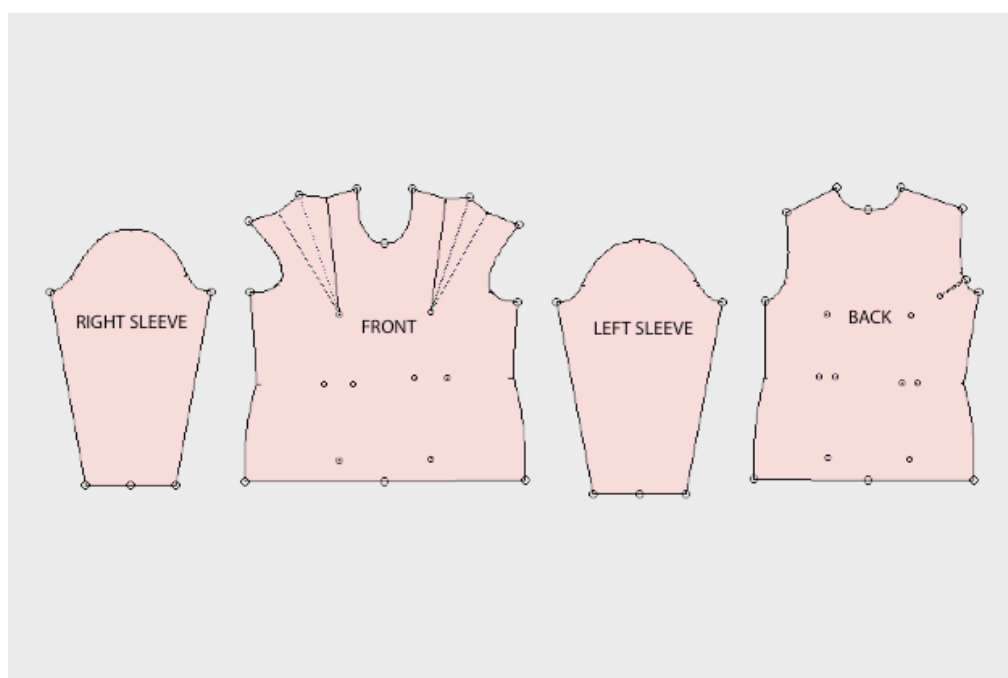


Figure 9.2. **S1L-Bodice-C₃RRTS_{TL}** pattern block, constructed using pattern profiles derived automatically via *PolyPatternM2M* made-to-measure automated software

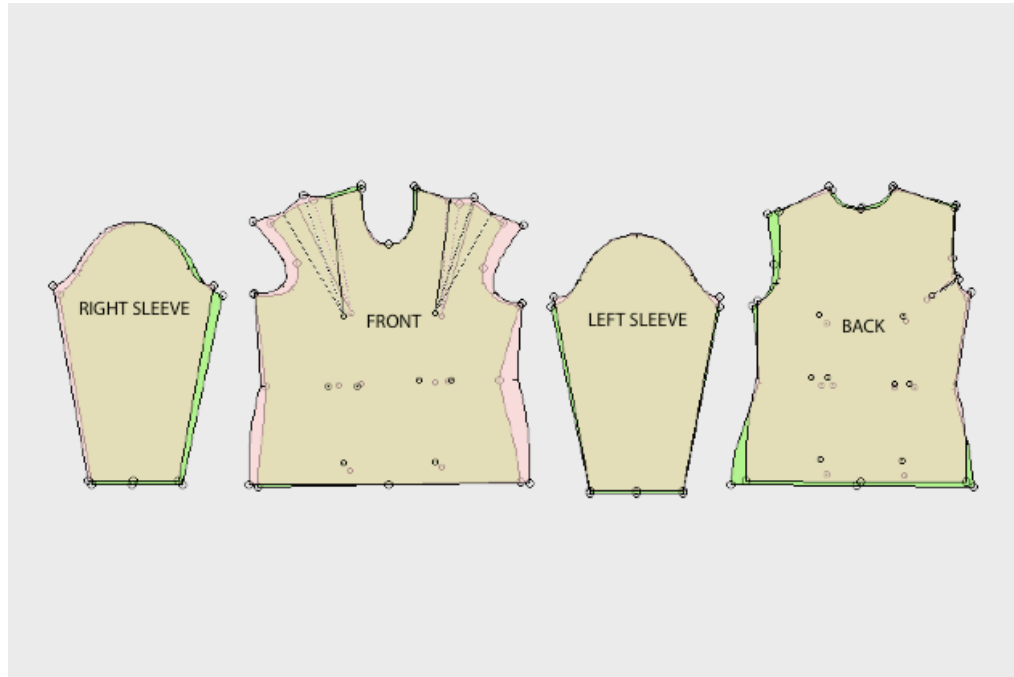


Figure 9.3. A comparison between manually designed & automatically derived pattern blocks for **S1L-Bodice-C₃RRTsTL**¹¹⁴

The 'front shoulder tip width' and 'front left side seam' differences between the two blocks occur due to the fact that the left bust and waist darts are wider in the 'PolypatternM2M' block.

The 'front hip width' and 'back hip width' differences derive from the fact that the 'front waist dart widths' and the 'back waist dart widths' were different for each of the two 'Basic Bodice' pattern blocks: the manually designed 'Basic Front Bodice' block has smaller waist darts than the 'PolyPatternM2M' block, while the manually designed 'Basic Back Bodice' block is wider in the hip area, resulting in a far from aesthetically pleasing shape for the back side-seams.

Moreover, after a consistent check of the two 'front blocks' it was found that the wider bust darts provided a better fit around the bust, while the wider front waist darts provided

¹¹⁴ **S1L-Bodice-C₃RRTsTL** pattern blocks designed manually are indicated with green colour. **S1L-Bodice-C₃RRTsTL** pattern blocks derived via 'PolyPatternM2M' are indicated with pink colour. Beige colour indicates their intersecting areas.

a more acceptable pattern shape for the front side seams, in the '*PolyPatternM2M*' pattern block.

To sum up, both '*left and right sleeve crown height*' distance differences vary from 1.00cm to 1.75cm, which are considered minimum differences, perfectly justified, owing to the two different pattern construction methods used. In general, the '*PolypatternM2M*' basic blocks proved to be more than accurate in terms of measurements and fit.

9.2. 2nd Experimental Study

As mentioned above, the final stage of my research was to gather the median measurements for the **C₁₋₂₋₃R_{R-L}T_SS_{TL}** groups and the **C₁₋₂₋₃R_{R-L}T_CS_T** groups (Tables 7.20cdef & 7.19cd - Appendix B) and generate basic pattern blocks for each garment style (bodice, skirt, dress, trousers), derived from these measurements. In order to obtain accurate results for *median* findings, '*Microsoft Excel*' software (Microsoft Office) was utilised, to facilitate the gathering of subject groups' median measurements.

Furthermore, in order to determine whether pattern blocks based on *median* measurements represent correctly designed patterns, able to provide a good fit for each subject belonging to the same scoliotic group, separately, I attempted the **second experimental study**. This study involved the construction of four different sets of basic Bodice pattern blocks, based on each of the 3 subjects' personal measurements (*Subjects 3, 4 and 74*) belonging to the size **M**, '**C₃R_RT_SS_{TL}**' Group - **S3M-Bodice-C₃R_RT_SS_{TL}**, **S4M-Bodice-C₃R_RT_SS_{TL}** and **S74M-Bodice-C₃R_RT_SS_{TL}** (Figure 9.4) - as well as on the group's general median measurements (Table 7.20e – Appendix B) - **AVGM-Bodice-C₃R_RT_SS_{TL}** (Figure 9.5) - and the comparison between them (Figure 9.6).

The '**C₃R_RT_SS_{TL}**' Group was chosen because *Subjects* 3 and 4 were classified as such, so it was the first group formed (consisting of more than one subject), in this research project. The aim of this second experimental study was to check whether the *Median Basic Bodice* block, in size **M** (**AVGM-Bodice-C₃R_RT_SS_{TL}**), could provide a good fit for each one of the three subjects belonging to this group (3, 4 and 74), *separately*.



Figure 9.4. A pattern comparison between **S3M-Bodice-C₃R_RT_SS_{TL}**, **S4M-Bodice-C₃R_RT_SS_{TL}** and **S74M-Bodice-C₃R_RT_SS_{TL}**

Figure 9.4 shows a comparison of Basic Bodice pattern blocks of the three different subjects (3, 4 and 74), which although having proportional and postural differences, were all classified as size **M**, according to the *Greek Generic Size Chart* (Table 7.12, pp.272), by many different sizing systems (See Table 7.7: 267).

It is evident that there are some differences between the three sets of Bodice blocks, classified as Size **M**, in the '**C₃R_RT_SS_{TL}**' Group, while the **S3M-Bodice-C₃R_RT_SS_{TL}** and

S74M-Bodice-**C₃R_RT_SS_{TL}** pattern blocks (yellow and green colour, respectively) seem to be closer to **AVGM**-Bodice-**C₃R_RT_SS_{TL}** pattern block, since *Subject-3* and *Subject-74* measurements are closer to the group's *median* measurements.



Figure 9.5. **AVGM**-Bodice-**C₃R_RT_SS_{TL}**¹¹⁶

Figure 9.5 depicts the **AVGM**-Bodice-**C₃R_RT_SS_{TL}** pattern block, derived from the median measurements of the **C₃R_RT_SS_{TL}** group for size **M**, while Figure 9.6, below, indicates that the **AVGM**-Bodice-**C₃R_RT_SS_{TL}** pattern block could provide a good fit for each of *Subjects* 3, 4 and 74, separately, given that the amount of ease would be a little different for each subject. For example, the **AVGM**-Bodice-**C₃R_RT_SS_{TL}** pattern block would be a bit large for *subject* 4, while it would provide a better fit for *Subject* 3 or *Subject* 74.

¹¹⁵ **S3M**-Bodice-**C₃R_RT_SS_{TL}** is indicated with yellow colour, **S4M**-Bodice-**C₃R_RT_SS_{TL}** is indicated with blue colour and **S74M**-Bodice-**C₃R_RT_SS_{TL}** is indicated with green colour.

¹¹⁶ **AVGM**-Bodice-**C₃R_RT_SS_{TL}** is indicated with lilac colour.

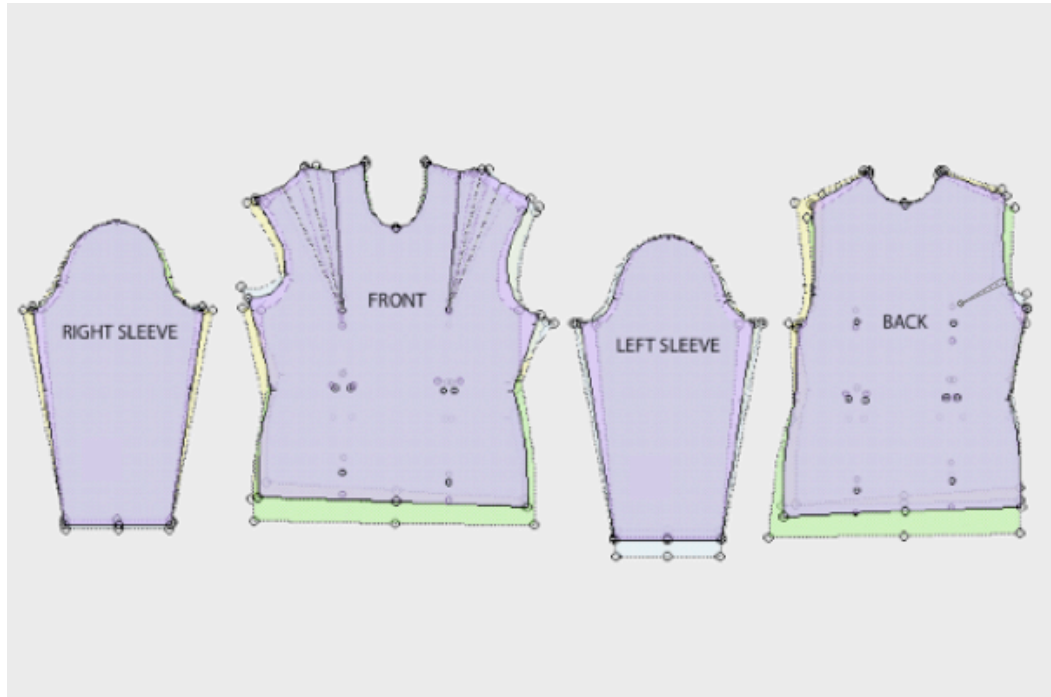


Figure 9.6. A comparison between **S3M-Bodice-C₃R_RT_SS_{TL}**, **S4M-Bodice-C₃R_RT_SS_{TL}**, **S74M-Bodice-C₃R_RT_SS_{TL}** and **AVGM-Bodice-C₃R_RT_SS_{TL}** pattern blocks

This, however, does not necessarily mean that the **AVGM-Bodice-C₃R_RT_SS_{TL}** is not an accurate Basic Bodice pattern block. This shows, basically, how mass-production in apparel industry operates. For example, a size *Medium* Bodice pattern block does not provide a perfect fit for all body types that are classified as size *Medium*. Some garments fit better on a certain group of people, who consider themselves as a size *Medium*, while the same garments may not provide a good fit or aesthetically pleasing looks for another group of people, who also claim to be a size *Medium*.

9.3. 3rd Experimental Study

In order to determine whether *basic Bodice pattern blocks*, based on median measurements, could be graded in a conventional way, I attempted the **third experimental study**, involving the construction of size **S**, size **M** and size **L Median**

Basic Bodice pattern blocks belonging to the '**C₃R_RT_SS_{TL}**' group (**AVGS-Bodice-C₃R_RT_SS_{TL}**, **AVGM-Bodice-C₃R_RT_SS_{TL}** and **AVGL-Bodice-C₃R_RT_SS_{TL}**) (Figures 9.8, 9.5 and 9.2, respectively) -- and a pattern comparison between them (Figure 9.10).

This study was also based on the '**C₃R_RT_SS_{TL}**' group, since it was the first group that was formed in this research project. The specific group consisted of only three sizes: **S**, **M** and **L** – there weren't any subjects classified as XS or XL in this group.

The **AVGS-Bodice-C₃R_RT_SS_{TL}** pattern block (Figure 9.8) was derived from the **C₃R_RT_SS_{TL}** group's median measurements for size **S**, while Figure 9.7 depicts the basic bodice pattern blocks for *Subject 30* and *Subject 35*. Finally, Figure 9.9 depicts the comparison between **S30S-Bodice-C₃R_RT_SS_{TL}**, **S35S-Bodice-C₃R_RT_SS_{TL}** and **AVGS-Bodice-C₃R_RT_SS_{TL}** pattern blocks.

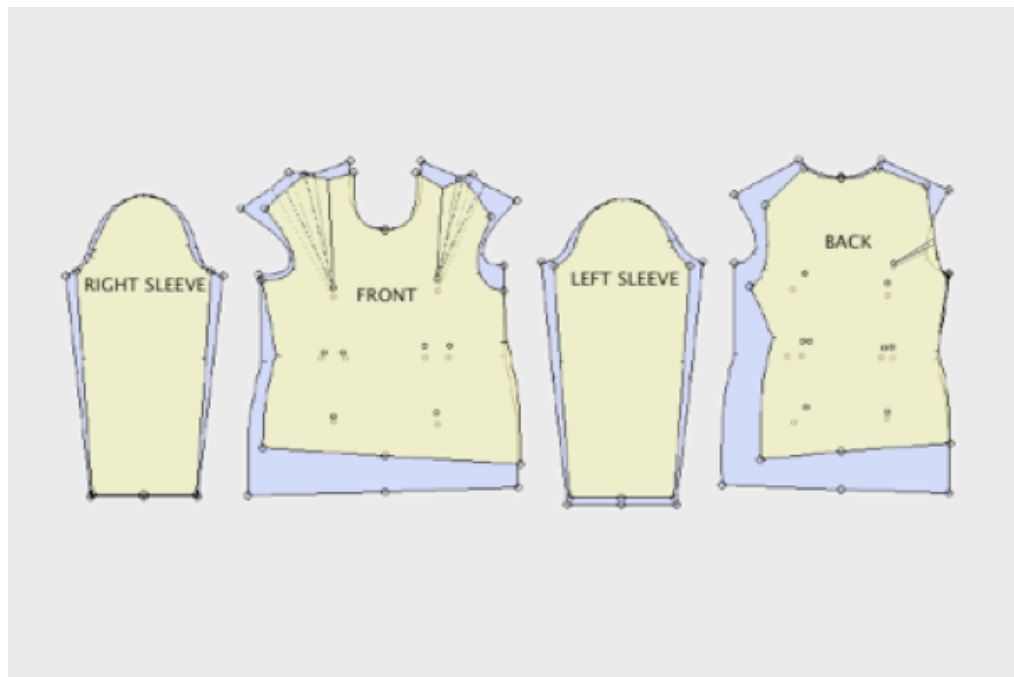


Figure 9.7. **S30S-Bodice-C₃R_RT_SS_{TL}** and **S35S-Bodice-C₃R_RT_SS_{TL}** pattern blocks¹¹⁷

¹¹⁷ **S30S-Bodice-C₃R_RT_SS_{TL}** is indicated with yellow colour and **S35S-Bodice-C₃R_RT_SS_{TL}** is indicated with light blue colour



Figure 9.8. The **AVGS-Bodice-C₃RRTsTL** pattern block¹¹⁸



Figure 9.9. A pattern comparison between **S30S-Bodice-C₃RRTsTL**, **S35S-Bodice-C₃RRTsTL** and **AVGS-Bodice-C₃RRTsTL** pattern blocks¹¹⁹

¹¹⁸ **AVGS-Bodice-C₃RRTsTL** is indicated with pistachio colour.

¹¹⁹ **S30S-Bodice-C₃RRTsTL** is indicated with yellow colour, **S35S-Bodice-C₃RRTsTL** is indicated with light blue colour and **AVGS-Bodice-C₃RRTsTL** is indicated with pistachio colour.

It is evident from Figure 9.9 that the **AVGS-Bodice-C₃R_RT_SS_{TL}** block could fit both *Subjects 30* and *35*, separately, as it lies between them, given that the amount of ease would be different for each subject: the **AVGS-Bodice-C₃R_RT_SS_{TL}** block would be tighter for *Subject 35*, while it would be looser for *Subject 30* (for ease allowances see Table 8.1 – Appendix C).

Overall, Figure 9.10, below, depicts the grading from size **S** to size **M** and to size **L**, indicating the size differences between size **S**, **M** and **L** Median Basic Bodice pattern blocks (**AVGS-Bodice-C₃R_RT_SS_{TL}**, **AVGM-Bodice-C₃R_RT_SS_{TL}** and **AVGL-Bodice-C₃R_RT_SS_{TL}**).



Figure 9.10. Grading the **AVGS-Bodice-C₃R_RT_SS_{TL}** to **AVGM-Bodice-C₃R_RT_SS_{TL}** and to **AVGL-Bodice-C₃R_RT_SS_{TL}**, using each time a different size, as base size, in the three different nested representations¹²⁰

¹²⁰ **AVGS-Bodice-C₃R_RT_SS_{TL}** is indicated with pink colour.
AVGM-Bodice-C₃R_RT_SS_{TL} is indicated with blue colour.

The grading pattern between the **AVGS-Bodice-C₃R_RT_SS_{TL}**, the **AVGM-Bodice-C₃R_RT_SS_{TL}** and the **AVGL-Bodice-C₃R_RT_SS_{TL}** (Figure 9.10), does not follow conventional grading rules of increment, from smaller to larger sizes – that are supposed to be the same for right and left side of the body – a fact that supports the findings of a study by Bye *et al.* (Fig.1, 2008:83), which indicated that in order to achieve optimum grading within a size range, grading practices should include measurement and shape variations. In conclusion, the shapes of the patterns (of all sizes) in Figure 9.10 correspond to the shapes of the patterns constructed, according to Frost's or Chase & Quinn's methods (Frost, 1987:30; Chase & Quinn, 2003:84-86), in order to accommodate a figure with an asymmetric body configuration, due to scoliosis of the spine (Figures 5.1 & 5.2, Chapter 5.2, pp.130-132).

9.4. 4th Experimental Study

The **fourth experimental study** involved the grading of *Median Basic Bodice* pattern blocks, belonging to the '**C₁R_RT_SS_{TL}**' group, in sizes **S**, **M**, **L** and **XL** (**AVGS-Bodice-C₁R_RT_SS_{TL}**, **AVGM-Bodice-C₁R_RT_SS_{TL}**, **AVGL-Bodice-C₁R_RT_SS_{TL}** and **AVGXL-Bodice-C₁R_RT_SS_{TL}**) (Figures 9.11, 9.12, 9.13 and 9.14, respectively).

The '**C₁R_RT_SS_{TL}**' group consisted of four sizes (**S**, **M**, **L** and **XL**) – as there were not any subjects classified as **XS** in this group – and it was chosen due to the fact that it was **the most populated group** in this research project (23 out of 74 subjects ~ almost 1/3 of the whole sample).

AVGL-Bodice-C₃R_RT_SS_{TL} is indicated with lilac colour.

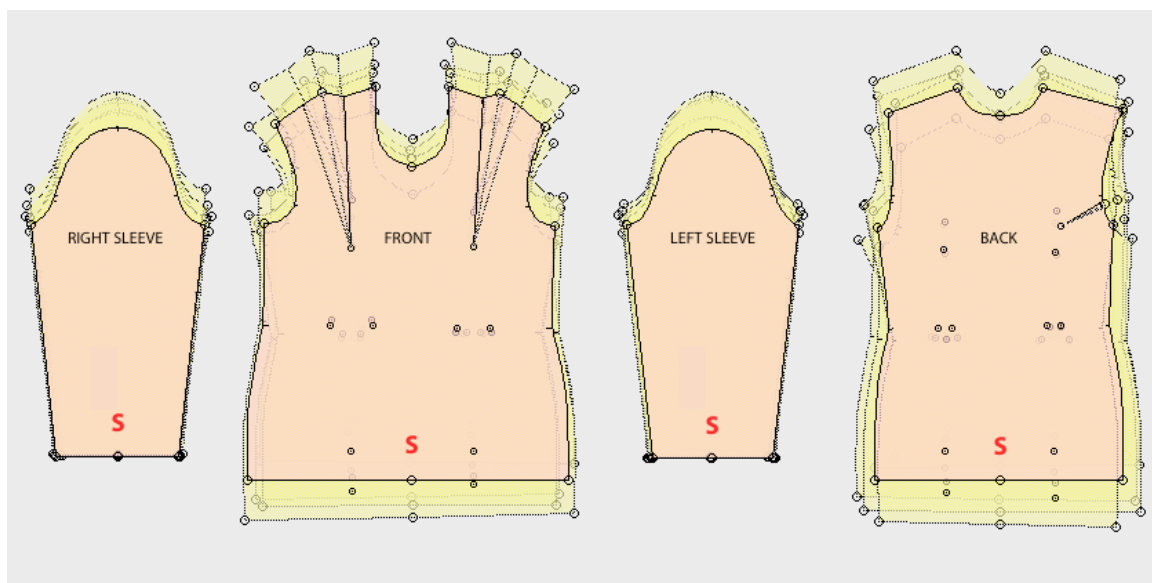


Figure 9.11. The **AVGS-Bodice-C₁R_RT_ST_L** pattern block
(compared to bodice pattern blocks for subjects: 26, 41, 58, 62, 65)¹²¹

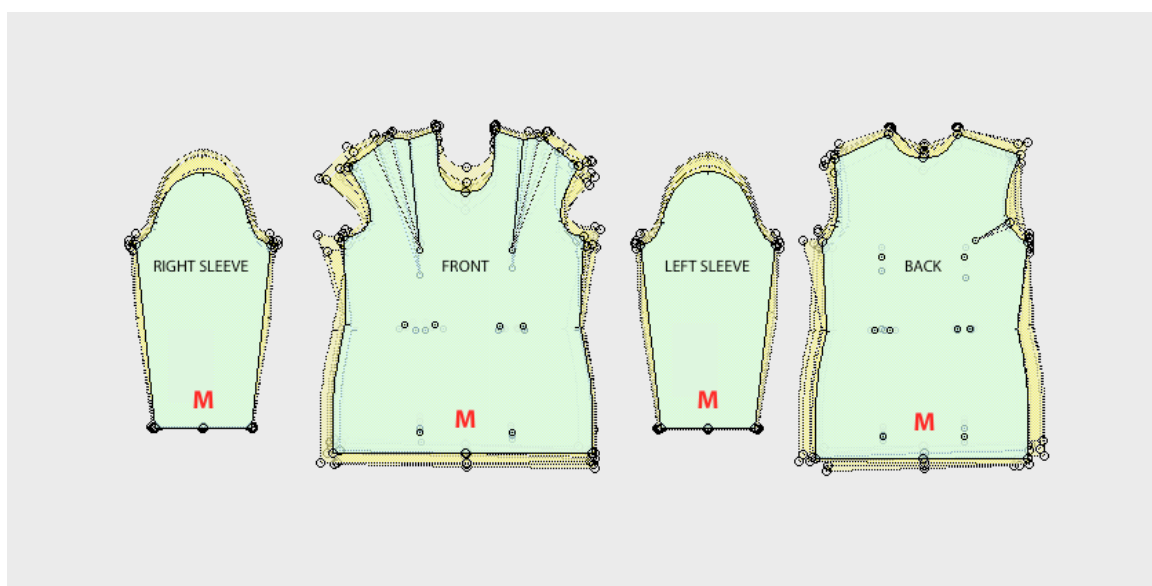


Figure 9.12. The **AVGM-Bodice-C₁R_RT_ST_L** pattern block
(compared to bodice pattern blocks for subjects: 13, 14, 20, 32, 36, 38, 57, 59, 60, 61, 66)¹²²

¹²¹ **AVGS-Bodice-C₁R_RT_ST_L** is indicated with pink colour

¹²² **AVGM-Bodice-C₁R_RT_ST_L** is indicated with blue colour

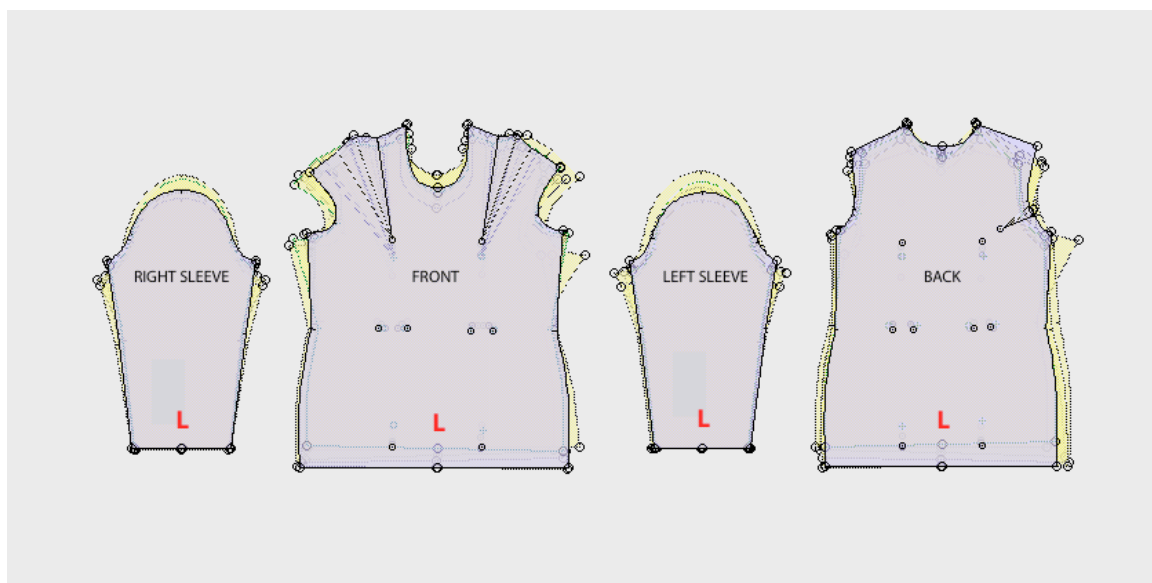


Figure 9.13. The **AVGL-Bodice-C₁R_RT_ST_L** pattern block
(compared to bodice pattern blocks for subjects: 19, 21, 39, 49, 54)¹²³



Figure 9.14. The **AVGXL-Bodice-C₁R_RT_ST_L** pattern block
(compared to bodice pattern blocks for subjects: 12 & 42)¹²⁴

¹²³ **AVGL-Bodice-C₁R_RT_ST_L** is indicated with lilac colour

¹²⁴ **AVGXL-Bodice-C₁R_RT_ST_L** is indicated with orange colour

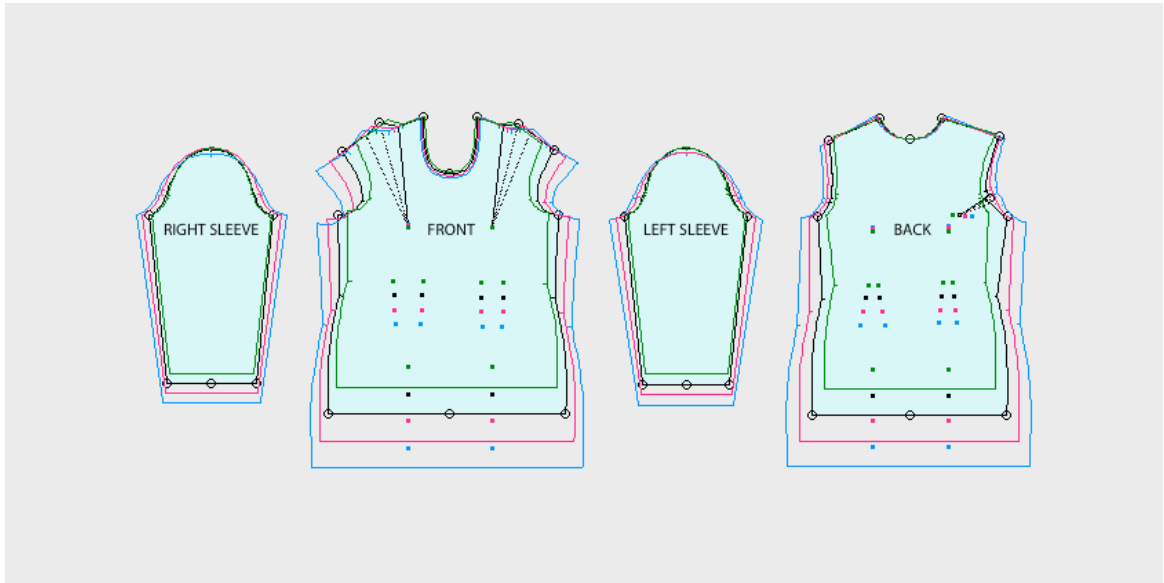


Figure 9.15. Grading the **AVGS-Bodice-C₁R_RT_SS_{TL}** to **AVGM-Bodice-C₁R_RT_SS_{TL}**, to **AVGL-Bodice-C₁R_RT_SS_{TL}** and to **AVGXL-Bodice-C₁R_RT_SS_{TL}**, using size **M** as base size

Figure 9.15 depicts the grading pattern of **AVGS-Bodice-C₁R_RT_SS_{TL}**, **AVGM-Bodice-C₁R_RT_SS_{TL}**, **AVGL-Bodice-C₁R_RT_SS_{TL}** and **AVGXL-Bodice-C₁R_RT_SS_{TL}** from smaller to larger sizes. Figure 9.15 indicates that there does not appear to be any increment patterning among the four different sizes, which could follow conventional grading rules (especially around the 'right back scye' area: right back full-bust width, Measur. 12d, Table 7.1, Chapter 7.3.2) – a fact that supports, once again, the findings of the study by Bye *et al.* (Fig.1, 2008:83), suggesting that in order to achieve optimum grading within a size range, grading practices should include measurement and shape variations.

9.5. 5th Experimental Study

Furthermore, in order to determine whether pattern blocks derived from *median* measurements of subjects belonging to different body sizes, of a three different-curve sized scoliotic group, could be further graded in multiple size sets (drop sizes), according

to their scoliotic curve size, I attempted the **fifth experimental study**, concerning the most populated scoliotic group in this study (the **C₁₋₂₋₃R_RT_SS_{TL}** group).

The '**C₂R_RT_SS_{TL}**' Group had no subjects at all classified as sizes **XS**, **L** or **XL**, while the '**C₃R_RT_SS_{TL}**' Group had no subjects at all classified as sizes **XS** or **XL** and only one subject (*Subject 1*) representing size **L**. Evidently, sizes **XS**, **L** and **XL** were omitted from this grading attempt in '*drop sizes*' for the **C₁₋₂₋₃R_RT_SS_{TL}** group, while due to small participant count in the **XS**, **L** and **XL** size category, for all 3 groups, the analysis focused on the patterns for the **S** and **M** size category – involving the comparison of the three different curve-sized *Median Basic Bodice* pattern blocks in size **S** (**AVGS-Bodice-C₁R_RT_SS_{TL}**, **AVGS-Bodice-C₂R_RT_SS_{TL}** and **AVGS-Bodice-C₃R_RT_SS_{TL}**) (Figure 9.16) and the three different curve-sized *Median Basic Bodice* pattern blocks in size **M** (**AVGM-Bodice-C₁R_RT_SS_{TL}**, **AVGM-Bodice-C₂R_RT_SS_{TL}** and **AVGM-Bodice-C₃R_RT_SS_{TL}**) (Figure 9.17).

NOTE: A comparison concerning a grading attempt in '*drop sizes*' for the **C₁₋₂₋₃R_RT_CS_T** group (the second most populated group in this study), involving the *Median Basic Bodice* pattern blocks in all sizes, was not feasible, due to the limited number of subjects classified: the '**C₂R_RT_CS_T**' Group had no subjects classified in any of the five body sizes, while the '**C₃R_RT_SS_{TL}**' Group had only one subject (*Subject 75*) classified, as such, representing size **M**.

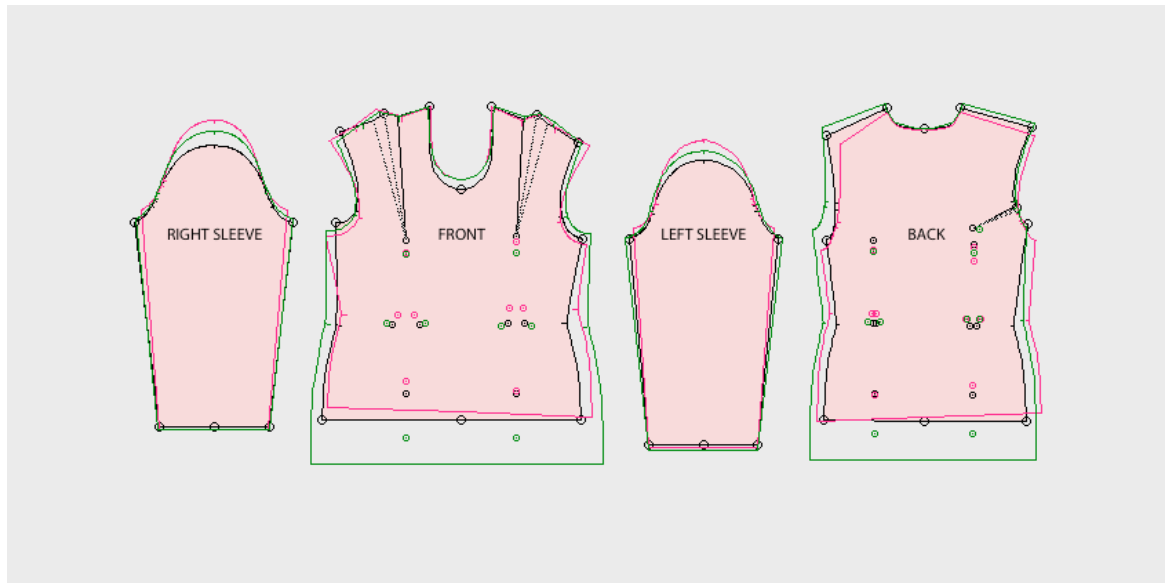


Figure 9.16. **AVGS-Bodice-C₁R_RT_ST_L** graded to **AVGS-Bodice-C₂R_RT_ST_L** and to **AVGS-Bodice-C₃R_RT_ST_L**, using the **AVGS-Bodice-C₂R_RT_ST_L** pattern block as base size¹²⁵

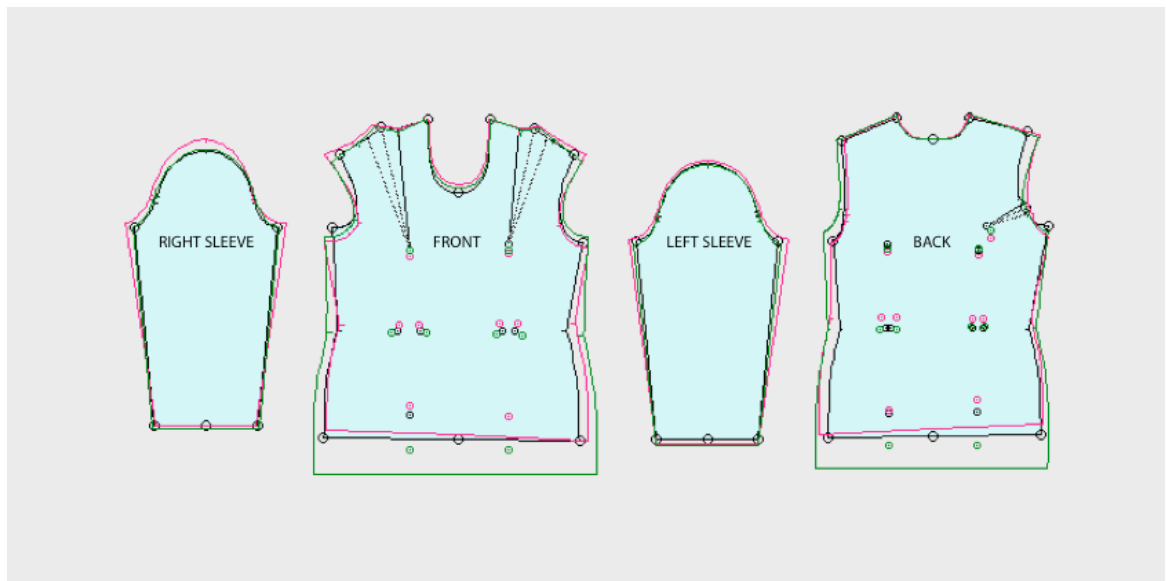


Figure 9.17. **AVGM-Bodice-C₁R_RT_ST_L** graded to **AVGM-Bodice-C₂R_RT_ST_L** and to **AVGM-Bodice-C₃R_RT_ST_L**, using the **AVGM-Bodice-C₂R_RT_ST_L** pattern block as base size¹²⁶

¹²⁵ **AVGS-Bodice-C₁R_RT_ST_L** pattern outline is indicated with pink colour, **AVGS-Bodice-C₃R_RT_ST_L** pattern outline is indicated with green-colour, while the **AVGS-Bodice-C₂R_RT_ST_L** pattern block is used as base size

It is evident from Figures 9.16 and 9.17 that a grading in ‘drop sizes’ is quite possible, owing to the fact that there are only slight differences widthways, but rather evident differences lengthways¹²⁷, regarding the patterns’ dimensions between, both, three different curve-sized **S** and **M** body sizes, for the **C₁₋₂₋₃R_RT_SS_{TL}** group.

At this point, it is interesting to note that Curve Size 1 *Median front and back Bodice pattern blocks* are the longest, whereas Curve size 3 are the shortest and Curve size 2 front and back bodice pattern blocks lie in between, in terms of length, for both **S** and **M** body sizes.

The right back midscye dart location, thus, could be calculated based on sample data (each curve size group’s *median* body measurements), by looking at the dart length and dart width variation within each *curve size group*, and how it affects various other critical body measurements used in pattern design, such as *height of shoulder slope, shoulder length, armscye depth, armhole circumference, sleeve crown*, etc.

The *shoulder length* body measurement is linked to the *shoulder area* of the *sleeve* pattern and the *arm length* body measurement is linked to the *length* of the *sleeve*.

Hence, *right/left arm/underarm lengths, right/left armscye depths, right/left heights of shoulder slopes, right/left armhole circumferences, right/left widths (half across back), right/left and front/back widths (shoulder-tip, high-bust, full-bust, under-bust, midriff and waist width)*, as well as other *right-left and front/back diagonal measurements (shoulder length and shoulder slope)* were calculated and compared, while the tendencies of the data points are visible in Tables 9.6 and 9.7 (Appendix C), which provide the correlation matrices – derived from PCA Tables 7.21 & 7.22 (Appendix B) and Tables 9.4 & 9.5

¹²⁶ **AVGM-Bodice-C₁R_RT_SS_{TL}** pattern outline is indicated with pink colour, **AVGM-Bodice-C₃R_RT_SS_{TL}** pattern outline is indicated with green-colour, while the **AVGM-Bodice-C₂R_RT_SS_{TL}** pattern block is used as base size

¹²⁷ Due to limited amount of subjects in each scoliotic curve size group, this research was bound to have only approximate results.

(Appendix C) – concerning the whole sample (75 subjects with various types of scoliosis) and the **C₁₋₂₋₃R_RT_SS_{TL}** groups, respectively.

Table 9.6 (whole sample - Appendix C) shows a general tendency that there are two types of strong correlations, involving *8 measurements*, in total. The first type indicates that all the right back width measurements around the thorax, bust, midriff and waist area (11d, 12d, 14d, 15d, 16d) are strongly correlated to each other (Pearson $n > 0.75$), while the second type indicates that there are strong correlations (Pearson $n > 0.75$) between certain length measurements concerning the right shoulder, thorax, midriff and waist, such as: the diagonal measurement of the right back shoulder tip to the centre of the waist (36d), the total height of the right neck point – front and back (38b) and the length measurement running down from C2 to C3, starting at the shoulder-line and ending at the waist-line, that goes over the peak (C1) of the scoliotic curvature (54d).

After studying and comparing the three different matrices of Table 9.7 (**C₁₋₂₋₃R_RT_SS_{TL}** groups - Appendix C), it was found that, concerning all three curve-size groups, there are two types of correlations (strong or partial), involving *12 measurements*, in total. The first type indicates that all the right back width measurements around the thorax, bust, back, midriff and waist area (11d, 12d, 14d, 15d, 16d) are strongly or partially correlated to each other ($0.5 > \text{Pearson } n > 0.75$).

The second type indicates that there are strong correlations (Pearson $n > 0.75$) between certain length measurements around the right shoulder, thorax, midriff and waist, such as: the back right full bodice length (3d), the right side seam length to waist (17b), the diagonal measurement of the right back shoulder tip to the centre of the waist (36d), the total height of the right neck point – front and back (38b), the total height of the right shoulder point – front and back (39b) and the length measurement running down from C2 to C3, starting at the shoulder-line and ending at the waist-line, that goes over the

peak (C1) of the scoliotic curvature (54d). In addition, the last measurement (54d), only, is strongly correlated (Pearson $n > 0.75$) to the length measurement running down from C1 to C3 that starts at the peak of the scoliotic curvature and ends at the waistline (54c).

Given that *median values* identify the *base size* (size **M**), Tables 9.8 (Appendix C) and Table 9.9 (below) provide the *median* measurement values for the 3 different Curve Sizes, belonging to size **M** and their *strong* or *partial correlations* with other variables (based on Table 9.7 – Appendix C) for the **C₁₋₂₋₃R_RT_SS_{TL}** group, as all three curve-size groups (Figure 9.17) were populated with subjects in size **M**:

Table 9.9 (**C₁₋₂₋₃R_RT_SS_{TL}** group)

R_RT_SS_{TL} Group	CURVE SIZE 1	CURVE SIZE 2	CURVE SIZE 3
3d	41-» 21.5, 42.5, 83, 71.5, 40.5	40.5-» 23, 42, 79.5, 71, 40.5	40.75-» 19, 39.5, 76.25, 65.75, 37.75
11d	21-» 20, 19	22-» 21, 19	21.25-» 20.25, 19.5
12d	20-» 21, 19, 18.5	21-» 22, 19, 18.5	20.25-» 21.25, 19.5, 18.75
14d	19-» 21, 20, 18.5	19-» 22, 21, 18.5	19.5-» 21.25, 20.25, 18.75
15d	18.5-» 20, 19, 18	18.5-» 21, 19, 17.5	18.75-» 20.25, 19.5, 17.5
16d	18-» 18.5	17.5-» 18.5	17.5-» 18.75
17b	21.5-» 71.5, 40.5	23-» 71, 40.5	19-» 65.75, 37.75
36d	42.5-» 41, 83, 71.5, 40.5	42-» 40.5, 79.5, 71, 40.5	39.5-» 40.75, 76.25, 65.75, 37.75
38b	83-» 41, 42.5, 71.5, 40.5	79.5-» 40.5, 42, 71, 40.5	76.25-» 40.75, 39.5, 65.75, 37.75
39b	71.5-» 41, 21.5, 42.5, 83, 40.5	71-» 40.5, 23, 42, 79.5, 40.5	65.75-» 40.75, 19, 39.5, 76.25, 37.75
54c	19.5-» 40.5	21-» 40.5	17.5-» 37.75
54d	40.5-» 41, 21.5, 42.5, 83, 71.5, 19.5	40.5-» 40.5, 23, 42, 79.5, 71, 21	37.75-» 40.75, 19, 39.5, 76.25, 65.75, 17.5

Tables 9.8 (Appendix C) & 9.9 (above) indicate how one measurement's values affect the values of the other measurements strongly correlated to them. According to Table 9.9, all five right back width measurements (11d, 12d, 14d, 15d & 16d), belonging to the three different-severity curve sizes of Size **M**, demonstrate very small fluctuations, between 0.25cm to 1cm, mostly increasing or remaining the same from 'Curve Size 1' to 'Curve Size 2' and decreasing from 'Curve Size 2' to 'Curve Size 3'.

The length measurements, however, demonstrate steeper fluctuations (Figure 9.17), mostly between the two larger curve sizes (2 and 3). For example, the diagonal measurement of the right back shoulder tip to the centre of the waist (36d) decreases 2.5cm from 'Curve Size 2' to 'Curve Size 3', the length measurement running down from C1 to C3 (54c) decreases 3.5cm, the length measurement running down from C2 to C3 (54d) decreases 2.75cm, while the total height of the right neck point – front and back (38b) decreases 3.5cm and 3.25cm from 'Curve Size 1' to 'Curve Size 2' and from 'Curve Size 2' to 'Curve Size 3', respectively. Furthermore, the right side seam length to waist (17b) decreases 4cm from 'Curve Size 2' to 'Curve Size 3', while the total height of the right shoulder point – front and back (39b) decreases 5.25cm - a rather steep decrease between the two last different-severity Curve Sizes.

Therefore, after observing Figure 9.17 (pp.352) and studying Tables 9.7 & 9.8 (Appendix C) & 9.9 (pp.355), it is evident that **in order to accommodate a right thoraco-lumbar scoliosis, in terms of apparel pattern design, the length of the bodice pattern** (concerning the upper torso) **would be shortened, while the width would remain almost the same** (along the three different curve-sized Median Basic Bodice pattern blocks in size **M**), **as the scoliotic degrees increase** (from 'Curve Size 1' to 'Curve Size 3'), owing to the physical deformation and its impact on body shape.

This kind of tendencies proved that it would be possible to develop an objective calculation method, based on numerical parameters and mathematical formulas, because in general, body dimensions are proportional to each other, tending to show similar changes for similar body shapes.

9.6. 6th Experimental Study

As mentioned earlier (Chapter 7.5.4:277), given that left and right scoliosis types have been found to have the same clinical symptoms, despite the deformity's location side, I attempted the **sixth experimental study**, involving a pattern comparison between right and left 'Curve Size 1, S-type, Thoraco-lumbar Scoliosis' groups (**C₁R_{R-L}T_SS_{TL}**).

Hence, the **C₁R_RT_SS_{TL}** (right) Median Basic Bodice blocks in sizes **S**, **M**, **L** and **XL** (**AVGS-Bodice-C₁R_RT_SS_{TL}**, **AVGM-Bodice-C₁R_RT_SS_{TL}**, **AVGL-Bodice-C₁R_RT_SS_{TL}** and **AVGXL-Bodice-C₁R_RT_SS_{TL}**) were compared to the **C₁R_LT_SS_{TL}** (left) Median Basic Bodice blocks in sizes **S**, **M**, **L** and **XL** (**AVGS-Bodice-C₁R_LT_SS_{TL}**, **AVGM-Bodice-C₁R_LT_SS_{TL}**, **AVGL-Bodice-C₁R_LT_SS_{TL}** and **AVGXL-Bodice-C₁R_LT_SS_{TL}**) (Figure 9.18).

Although there weren't any subjects classified as size **S** in the '**C₁R_LT_SS_{TL}**' group, median measurements for the bodice block, in size **S**, were calculated by subtracting one standard deviation from the group's general median measurements (50th percentile: size **M**).

Figure 9.18 shows that the **C₁R_LT_SS_{TL}** compared to the **C₁R_RT_SS_{TL}** *Median Basic Bodice* pattern blocks seem to have a totally different grading pattern – the latter presenting a far smoother grading patterning than the former.

There is, however, a reasonable explanation for this: Sizes **M**, **L** and **XL** of the '**C₁R_LT_SS_{TL}**' group are represented, each, by one subject only (*Subject 55* as size **M**, *Subject 9* as size **L** and *Subject 40* as size **XL**), whereas there are no subjects at all classified as size **S**. Thus, there is not an adequate sample of subjects in any of the four different size groups for the 'left scoliotic' group, and consequently, *the Median Basic Bodice blocks* do not represent any *median* (average) body type belonging to the left scoliotic size groups.



Figure 9.18. '**C₁R_RT_SS_{TL}**' Median Basic Bodice blocks in sizes **S**, **M**, **L**, **XL** (top) compared to '**C₁R_LT_SS_{TL}**' Median Basic Bodice blocks in sizes **S**, **M**, **L**, **XL** (bottom)

Nevertheless, when I attempted to compare the **AVGM-Bodice-C₁R_LT_SS_{TL}** to the **AVGM-Bodice-C₁R_RT_SS_{TL}** pattern blocks (Figure 9.19), I found that if all the pattern blocks of **AVGM-Bodice-C₁R_LT_SS_{TL}** were being reflected vertically¹²⁸, they would, actually, result in **AVGM-Bodice-C₁R_RT_SS_{TL}** pattern blocks, with very slight differences between the two sets of pattern blocks (Figure 9.20), given that the sample of subjects was smaller for the 'left' than for the 'right' scoliotic group.

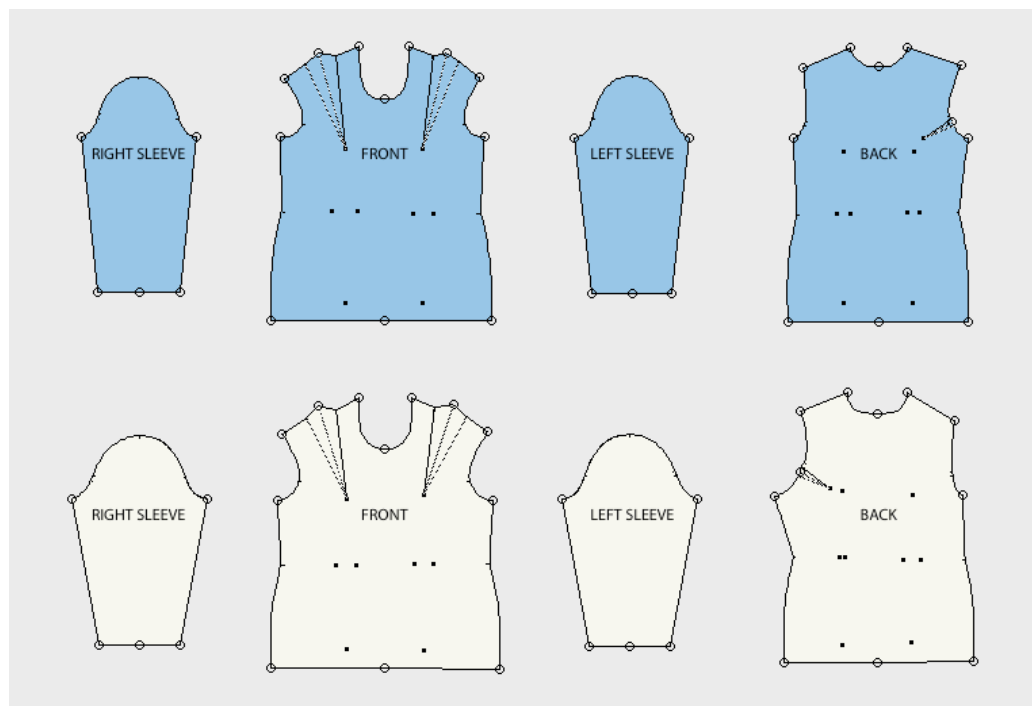


Figure 9.19. **AVGM-Bodice-C₁R_RT_SS_{TL}** compared to **AVGM-Bodice-C₁R_LT_SS_{TL}** pattern blocks¹²⁹

¹²⁸ **NOTE:** All pattern pieces should be reflected vertically, so that i.e. the left sleeve for **AVGM-Bodice-C₁R_LT_SS_{TL}** becomes the right sleeve for **AVGM-Bodice-C₁R_RT_SS_{TL}**, and vice versa.

¹²⁹ **AVGM-Bodice-C₁R_RT_SS_{TL}** is indicated with blue colour.
AVGM-Bodice-C₁R_LT_SS_{TL} is indicated with cream colour.

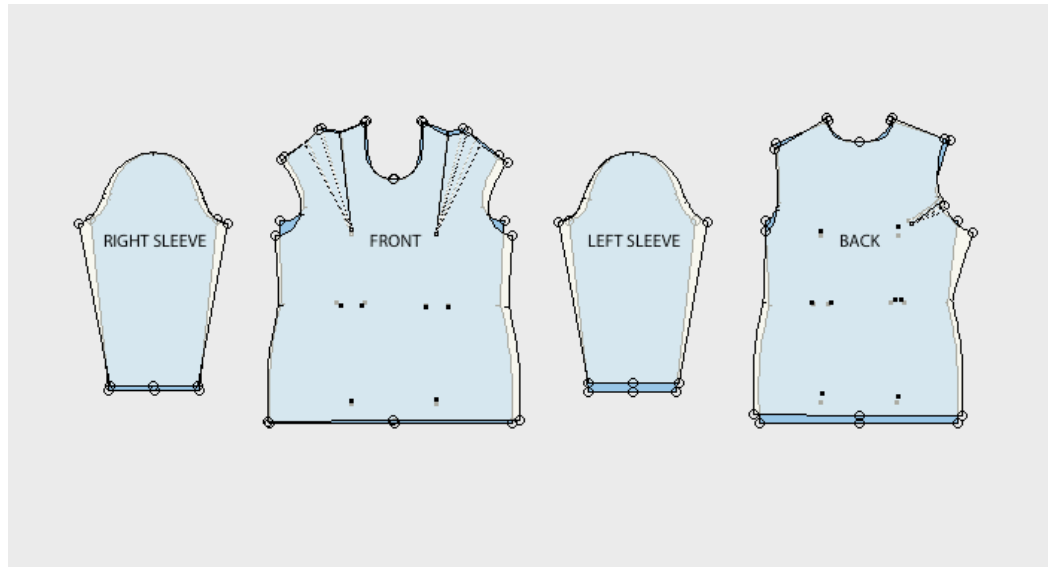


Figure 9.20. **AVGM-Bodice-C₁R_LT_SS_{TL}** pattern blocks on top of **AVGM-Bodice-C₁R_RT_SS_{TL}** pattern blocks, after all the pattern pieces of the former having been reflected vertically and placed onto the latter¹³⁰

To conclude, Figure 9.20 indicates that there are only very slight size differences between the 'left' and 'right scoliosis' pattern blocks (given the different amount of subjects in the two groups), demonstrating clearly that **the 180 scoliotic groups can, indeed, be reduced to half (90 groups), in terms of pattern design, owing to the fact that the pattern blocks for the left scoliotic groups can be reflected vertically, resulting in pattern blocks for the right scoliotic groups, and vice versa.**

The following chapter (Chapter 10) concerns the final stage of the process, the analysis and testing of the new sizing system, developed for adolescent girls with scoliosis, in order to generate information for improvements to the system. The developed size charts were evaluated, based on the level of fit provided for each of the different sizes, aiming to analyze the results of the evaluation and ideate a new prototype sizing system based on anthropometric data obtained from adolescent girls with various types of scoliosis.

¹³⁰ Light Blue colour indicates their intersecting areas.

Chapter 10

Fit Evaluation Results

10.1. Fit Evaluations based on the 'Aggregate Loss of Fit'

The Aggregate Loss of Fit - a method first introduced by McCullogh *et al.* (1998:492-499) and later used by Gupta and Gangadhar (2004), based on an easy-to-follow statistical model - was adopted for validating the size charts based on young women's with scoliosis body dimensions. According to Gupta and Gangadhar (2004), this method is based on a mathematical formula, calculating the average of the Euclidian distance around the three-dimensional space of the individuals from their allocated size (Gupta & Gangadhar, 2004:467). For example:

$$\text{Aggregate loss} = \left[\sum \sqrt{(\text{assigned bust} - \text{actual bust})^2 + (\text{assigned hip} - \text{actual hip})^2 + (\text{assigned waist} - \text{actual waist})^2} \right] / (\text{Number of individuals in the category})$$

Gupta & Gangadhar (2004:458-469) illustrate the ideal value for *aggregate loss of fit* by the *square root* of the number of body dimensions considered – allowing for ± 1 inch of the actual body dimension from the assigned size, based on *the Imperial system*. As this research is based on the *Metric system*, the ideal value for *aggregate loss of fit* is illustrated by the *square root* of the number of body dimensions considered (N) – allowing for $\pm 2.54\text{cm}$ (± 1 inch) *deviation* of the actual body dimension from the assigned size. Hence, for the calculation of the aggregate loss considering a number (N) of body dimensions, *the allowable aggregate loss* (ideal value = benchmark) *of the goodness of fit* would be:

$$2.54 \times \sqrt{N}, \text{ where } N = \text{number of principle body measurements} \\ (\text{Doustaneh, Gorji, \& Varsei, 2010:1360})$$

For example, for the calculation of the aggregate loss considering 3 body dimensions (i.e. bust-waist-hips), *the allowable aggregate loss of the goodness of fit*, i.e. the 'ideal value' (benchmark) for a good fit would be: $\sqrt{(3 \times 2.54^2)} = \sqrt{3} \times 2.54 = 1.73 \times 2.54 = 4.39\text{cm}$

Validation of the proposed size charts, for the two most common types of scoliosis (Tables 7.29 & 7.30, Chapter 7.6.3:297-298), was done based on different criteria for the four different garment styles, due to the fact that different sets of body measurements are relevant to each style (Table 9.3 – Appendix C). For example, *bust* may determine the size of an upper body garment such a shirt, while this measurement is not needed to determine the size of a skirt or a pair of trousers.

Therefore, a total of **25 body measurements** (described below, p.364-366) were recorded for each subject belonging to the two most populated scoliotic groups, including **21 linear** and **4 girth measurements**. Selection of the body dimensions used for validation was based on the Principal Components obtained earlier (key dimensions derived from PCA, Chapters 7.6.2 & 7.6.3 – Tables 7.25 & 7.26: Appendix B, for the **C₁R_RT_SS_{TL}** and the **C₁R_RT_CS_T** group, respectively). Along with the standard principal components (bust-waist-hips: measur. **12**, **16** and **20**, respectively - Table 7.1, Chapter 7.3.3), certain measurements determining the vertical skew, and therefore, defining scoliosis asymmetry (**8ab**, **9ab**, **17ab**, **18cd** and **42ab** - Table 7.1, Chapter 7.3.3), should be included in the mathematical formulas obtaining the '*Aggregate Loss of Fit*', in order to evaluate the final pattern fit. According to Gupta and Gangadhar (2004), body dimensions such as *arm length*, *arm scye*, *wrist*, *thigh*, *knee*, *ankle*, were not considered during the calculation of the *aggregate loss*, as they are not key dimensions for fit. However, optimization of these dimensions would be integral for a good size chart (Gupta & Gangadhar, 2004:467).

The values of aggregate loss of goodness of fit obtained for each subject, of every body size group, separately, as well as the average value of the aggregate loss for each garment style, were compared against the ideal value for good fit (benchmark), for every garment style (p.364-366) and were rated with a numeric assessment ranging from **1** (unsatisfactory) to **4** (satisfactory), based on the 68-95-99.7 rule, also known as the *three-sigma* rule or *empirical* rule.

According to this rule, if a data distribution is approximately normal then about 68% of the data values are within one standard deviation of the mean (mathematically, $\mu \pm \sigma$, where μ is the *arithmetic mean* or *expected ideal value*), about 95% are within two standard deviations ($\mu \pm 2\sigma$), and about 99.7% lie within three standard deviations ($\mu \pm 3\sigma$). Given that the *standard deviation* (σ) for this application is 2.54cm (1 inch), the ratings of fit would form as follows:

1. Ideal Value – 2.54cm \leq Aggregate loss of fit \leq Ideal Value + 2.54cm:

Satisfactory Fit (4)

2. Ideal Value – (2x2.54) cm \leq Aggregate loss of fit $<$ Ideal Value – 2.54cm AND
Ideal Value + 2.54cm $<$ Aggregate loss of fit \leq Ideal Value + (2x2.54) cm:

Moderate Fit (3)

3. Ideal Value – (3x2.54) cm \leq Aggregate loss of fit $<$ Ideal Value – (2x2.54) cm
AND
Ideal Value + (2x2.54) cm $<$ Aggregate loss of fit \leq Ideal Value + (3x2.54) cm:

Fit with Minor Problems (2)

4. Aggregate loss of fit $<$ Ideal Value – (3x2.54) cm
AND
Aggregate loss of fit $>$ Ideal Value + (3x2.54) cm: **Unsatisfactory Fit (1)**

Based on this method, multiple analyses of fit were carried out, for each garment style, using **16 measurements for the bodice, 18 for the dress, 6 for the skirt and 11 for the pair of trousers**, respectively. In detail:

- The ideal value for aggregate loss of goodness of fit for the **bodice** (Table 10.6, p.370), using **16 body measurements**, would be $\sqrt{(16 \times 2.54^2)}=10.16\text{cm}$ (Appendix E – Tables 10.1 & 10.2 for **C₁R_RT_SS_{TL}** group and **C₁R_RT_CS_T** group, respectively), while the formula would take the following form:

$$\begin{aligned} &\textbf{Aggregate loss (bodice) =} \\ &[\sum \sqrt{(\text{assigned full-bust} - \text{actual full-bust})^2 + (\text{assigned waist} - \text{actual waist})^2 +} \\ &(\text{assigned hip} - \text{actual hip})^2 + (\text{assigned nape-to-waist} - \text{actual nape-to-waist})^2 + \\ &(\text{assigned centre front bodice} - \text{actual centre front bodice})^2 + (\text{assigned left nape-} \\ &\text{to-bust point} - \text{actual left nape-to-bust point})^2 + (\text{assigned right nape-to-bust point} \\ &- \text{actual right nape-to-bust point})^2 + (\text{assigned left nape-to-waist front} - \text{actual left} \\ &\text{nape-to-waist front})^2 + (\text{assigned right nape-to-waist front} - \text{actual right nape-to-} \\ &\text{waist front})^2 + (\text{assigned left side-seam length to waist} - \text{actual left side-seam} \\ &\text{length to waist})^2 + (\text{assigned right side-seam length to waist} - \text{actual right side-} \\ &\text{seam length to waist})^2 + (\text{assigned left hip depth} - \text{actual left hip depth})^2 + \\ &(\text{assigned right hip depth} - \text{actual right hip depth})^2 + (\text{assigned front shoulder} \\ &\text{width} - \text{actual front shoulder width})^2 + (\text{assigned back shoulder width} - \text{actual} \\ &\text{back shoulder width})^2 + (\text{assigned neck base girth} - \text{actual neck base girth})^2] / \\ &(\text{Number of individuals in the category}) \end{aligned}$$

- The ideal value for aggregate loss of goodness of fit for the **dress** (Table 10.7, p.371), using **18 body measurements**, would be $\sqrt{(18 \times 2.54^2)}=10.77\text{cm}$ (Appendix E – Tables 10.1 & 10.2 for **C₁R_RT_SS_{TL}** group and **C₁R_RT_CS_T** group, respectively), while the formula would take the following form:

$$\begin{aligned} &\textbf{Aggregate loss (dress) =} \\ &[\sum \sqrt{(\text{assigned full-bust} - \text{actual full-bust})^2 + (\text{assigned waist} - \text{actual waist})^2 +} \\ &(\text{assigned hip} - \text{actual hip})^2 + (\text{assigned nape-to-waist} - \text{actual nape-to-waist})^2 + \end{aligned}$$

$$\begin{aligned} & (\text{assigned centre front bodice} - \text{actual centre front bodice})^2 + (\text{assigned left nape-} \\ & \text{to-bust point} - \text{actual left nape-to-bust point})^2 + (\text{assigned right nape-to-bust point} \\ & - \text{actual right nape-to-bust point})^2 + (\text{assigned left nape-to-waist front} - \text{actual left} \\ & \text{nape-to-waist front})^2 + (\text{assigned right nape-to-waist front} - \text{actual right nape-to-} \\ & \text{waist front})^2 + (\text{assigned left side-seam length to waist} - \text{actual left side-seam} \\ & \text{length to waist})^2 + (\text{assigned right side-seam length to waist} - \text{actual right side-} \\ & \text{seam length to waist})^2 + (\text{assigned left hip depth} - \text{actual left hip depth})^2 + \\ & (\text{assigned right hip depth} - \text{actual right hip depth})^2 + (\text{assigned front shoulder} \\ & \text{width} - \text{actual front shoulder width})^2 + (\text{assigned back shoulder width} - \text{actual} \\ & \text{back shoulder width})^2 + (\text{assigned left dress length-to-knee} - \text{actual left dress} \\ & \text{length-to-knee})^2 + (\text{assigned right dress length-to-knee} - \text{actual right dress length-} \\ & \text{to-knee})^2 + (\text{assigned neck base girth} - \text{actual neck base girth})^2] / \\ & (\text{Number of individuals in the category}) \end{aligned}$$

- The ideal value for aggregate loss of goodness of fit for the **skirt** (Table 10.8, p.372), **using 6 body measurements**, would be $\sqrt{(6 \times 2.54^2)}=6.2\text{cm}$ (Appendix E – Tables 10.1 & 10.2 for $C_1R_RT_S S_{TL}$ group and $C_1R_RT_C S_T$ group, respectively), while the formula would take the following form:

$$\begin{aligned} & \text{Aggregate loss (skirt) =} \\ & [\sum \sqrt{(\text{assigned waist} - \text{actual waist})^2 + (\text{assigned hip} - \text{actual hip})^2 + (\text{assigned left} \\ & \text{hip depth} - \text{actual left hip depth})^2 + (\text{assigned right hip depth} - \text{actual right hip} \\ & \text{depth})^2 + (\text{assigned left dress length-to-knee} - \text{actual left dress length-to-knee})^2 +} \\ & (\text{assigned right dress length-to-knee} - \text{actual right dress length-to-knee})^2] / \\ & (\text{Number of individuals in the category}) \end{aligned}$$

- The ideal value for aggregate loss of goodness of fit for the pair of **trousers** (Table 10.9, p.373), **using 11 body measurements**, would be $\sqrt{(11 \times 2.54^2)}=8.4\text{cm}$ (Appendix E – Tables 10.1 & 10.2 for $C_1R_RT_S S_{TL}$ group and $C_1R_RT_C S_T$ group, respectively), while the formula would take the following form:

$$\text{Aggregate loss (trousers) =}$$

$$\left[\sum \sqrt{(\text{assigned waist} - \text{actual waist})^2 + (\text{assigned hip} - \text{actual hip})^2 + (\text{assigned left hip depth} - \text{actual left hip depth})^2 + (\text{assigned right hip depth} - \text{actual right hip depth})^2 + (\text{assigned crotch length} - \text{actual crotch length})^2 + (\text{assigned left outside leg length} - \text{actual left outside leg length})^2 + (\text{assigned right outside leg length} - \text{actual right outside leg length})^2 + (\text{assigned left inside leg length} - \text{actual left inside leg length})^2 + (\text{assigned right inside leg length} - \text{actual right inside leg length})^2 + (\text{assigned front waist-to-floor} - \text{actual front waist-to-floor})^2 + (\text{assigned back waist-to-floor} - \text{actual back waist-to-floor})^2} \right] /$$

(Number of individuals in the category)

Hence, the values of aggregate loss of goodness of fit obtained for each subject of every body size group, separately, as well as the average value of the aggregate loss for each garment style, were compared against the '*benchmark*' (ideal value) for good fit, for every garment style (i.e. **10.16cm for the 'bodice'**, **10.77cm for the 'dress'**, **6.2cm for the 'skirt'** and **8.4cm for the 'trousers'**) (Appendix E - Tables 10.1 and 10.2 for the **C₁R_RT_SS_{TL}** group and the **C₁R_RT_CS_T** group, respectively).

The overall fit satisfaction for each garment style was then calculated, on the same 4-point scale (satisfactory fit – moderate fit – fit with minor problems – unsatisfactory fit, p.363), by obtaining the average fit rate from all the subjects, in all sizes, for each scoliotic group (Appendix E - Tables 10.1 and 10.2 for the **C₁R_RT_SS_{TL}** group and the **C₁R_RT_CS_T** group, respectively).

More specifically, for the calculation of the average aggregate loss of the **skirt's fit** for the **C₁R_RT_SS_{TL}** group, considering **6 body dimensions** (p.367), the square values obtained after subtracting the actual measurement of a specific body dimension from the assigned-to-that-size measurement of the particular body dimension, from each subject of every body size group (S, M, L and XL), separately, were (Table 10.3, below, and see also Appendix E - Table 10.1 for the **C₁R_RT_SS_{TL}** group):

Table 10.3

SUBJECTS BELONGING TO THE C ₁ R _R T _S S _{TL} group (all sizes)	SKIRT – 6 Measurements (Table 7.1, p.228)					
	02a*02a	02b*02b	18c*18c	18c*18c	18d*18d	20*20
Aggregate Loss of Fit - S26S	9	27.56	0	30.25	27.56	72.25
Aggregate Loss of Fit - S41S	2.25	5.06	16	12.25	18.06	0.25
Aggregate Loss of Fit - S58S	49	76.56	1	2.25	0.56	1
Aggregate Loss of Fit - S62S	6.25	14.06	4	12.25	7.56	1
Aggregate Loss of Fit - S65S	42.25	33.06	0	25.00	52.56	6.25
Aggregate Loss of Fit - S13M	2.25	4.00	25			
Aggregate Loss of Fit - S14M	72.25	49.00	16	2.25	1.00	16
Aggregate Loss of Fit - S20M	6.25	20.25	42.25	9.00	0.25	25
Aggregate Loss of Fit - S32M	144	169.00	49	4.00	1.00	25
Aggregate Loss of Fit - S36M	1	6.25	2.25	2.25	2.25	1
Aggregate Loss of Fit - S38M	20.25	2.25	30.25	1.00	0.00	90.25
Aggregate Loss of Fit - S57M	36	64.00	4	30.25	12.25	1
Aggregate Loss of Fit - S59M	6.25	12.25	36	1.00	9.00	64
Aggregate Loss of Fit - S60M	2.25	0.00	25	1.00	9.00	0
Aggregate Loss of Fit - S61M	81	64.00	2.25	4.00	9.00	42.25
Aggregate Loss of Fit - S66M	121	156.25	30.25	1.00	1.00	1
Aggregate Loss of Fit S19L	20.25	10.56	49	0.00	4.00	0.25
Aggregate Loss of Fit S21L	72.25	60.06	49			
Aggregate Loss of Fit S39L	56.25	45.56	72.25	6.25	3.06	6.25
Aggregate Loss of Fit S49L	1	0.56	36	12.25	7.56	4
Aggregate Loss of Fit S54L	30.25	39.06	42.25	1.00	0.06	12.25
Aggregate Loss of Fit S12XL	6.25	0.00	6.25	6.25	7.56	0.25
Aggregate Loss of Fit S42XL	240.25	182.25	1	12.25	22.56	4

These values were then compared against the ideal value for a good fit (**6.2cm**) for the skirt (Table 10.4, below, and see also Appendix E - Table 10.1 for the **C₁R_RT_SS_{TL}** group):

Table 10.4

Σ	$\sqrt{\Sigma}$	$\sqrt{\Sigma} / \text{individuals}$	ALF (SKIRT) - Metric Ideal ALF = 6.2 cm	
166.63	12.91		12.91	Aggregate Loss of Fit - S26S
53.88	7.34		7.34	Aggregate Loss of Fit - S41S
130.38	11.42		11.42	Aggregate Loss of Fit - S58S
45.13	6.72		6.72	Aggregate Loss of Fit - S62S
159.13	12.61		12.61	Aggregate Loss of Fit - S65S
	51.00	$\sqrt{\Sigma} / 5$	10.20	
50.50	7.11		7.11	Aggregate Loss of Fit - S13M
171.50	13.10		13.10	Aggregate Loss of Fit - S14M
98.75	9.94		9.94	Aggregate Loss of Fit - S20M
367.50	19.17		19.17	Aggregate Loss of Fit - S32M
100.75	10.04		10.04	Aggregate Loss of Fit - S36M
96.25	9.81		9.81	Aggregate Loss of Fit - S38M
178.00	13.34		13.34	Aggregate Loss of Fit - S57M
64.50	8.03		8.03	Aggregate Loss of Fit - S59M
82.50	9.08		9.08	Aggregate Loss of Fit - S60M
150.25	12.26		12.26	Aggregate Loss of Fit - S61M
311.75	17.66		17.66	Aggregate Loss of Fit - S66M
	129.53	$\sqrt{\Sigma} / 11$	11.78	
95.38	9.77		9.77	Aggregate Loss of Fit - S19L
205.13	14.32		14.32	Aggregate Loss of Fit - S21L
187.38	13.69		13.69	Aggregate Loss of Fit - S39L
51.63	7.19		7.19	Aggregate Loss of Fit - S49L
150.38	12.26		12.26	Aggregate Loss of Fit - S54L
	57.22	$\sqrt{\Sigma} / 5$	11.44	
222.75	14.92		14.92	Aggregate Loss of Fit - S12XL
447.00	21.14		21.14	Aggregate Loss of Fit - S42XL
	36.07	$\sqrt{\Sigma} / 2$	18.03	

Satisfaction from the skirt's fit for each subject, separately, as well as overall fit satisfaction for the skirt, was then calculated on the 4-point scale (satisfactory fit – moderate fit – fit with minor problems – unsatisfactory fit, p.363), by obtaining the average fit rate from all the subjects, in all sizes, for the **C₁R_RT_SS_{TL}** group (Table 10.5, below, and see also Appendix E - Table 10.1 for the **C₁R_RT_SS_{TL}** group).

Table 10.5

SKIRT FIT EVALUATION		
S26S	FIT WITH MINOR PROBLEMS	2
S41S	SATISFACTORY FIT	4
S58S	FIT WITH MINOR PROBLEMS	2
S62S	SATISFACTORY FIT	4
S65S	FIT WITH MINOR PROBLEMS	2
	Average ALF for SKIRT - SIZE S (MODERATE FIT)	3
S13M	SATISFACTORY FIT	4
S14M	FIT WITH MINOR PROBLEMS	2
S20M	MODERATE FIT	3
S32M	UNSATISFACTORY FIT	1
S36M	MODERATE FIT	3
S38M	MODERATE FIT	3
S57M	FIT WITH MINOR PROBLEMS	2
S59M	SATISFACTORY FIT	4
S60M	MODERATE FIT	3
S61M	FIT WITH MINOR PROBLEMS	2
S66M	UNSATISFACTORY FIT	1
	Average ALF for SKIRT - SIZE M (MODERATE FIT)	3
S19L	MODERATE FIT	3
S21L	UNSATISFACTORY FIT	1
S39L	FIT WITH MINOR PROBLEMS	2
S49L	SATISFACTORY FIT	4
S54L	FIT WITH MINOR PROBLEMS	2
	Average ALF for SIZE L (MINOR PROBLEMS FIT)	2
S12XL	UNSATISFACTORY FIT	1
S42XL	UNSATISFACTORY FIT	1
	Average ALF for SIZE XL (UNSATISFACTORY FIT)	1

To conclude, the overall fit of the skirt – including the 4 different sizes (S, M, L, XL) – according to the theoretical model based on the mathematical formula calculating the aggregate loss of fit (Table 10.5 above), was found to be with minor problems:

$$[(3+3+2+1) / 4] = 2.25 \approx 2$$

10.1.1. Results

Most of the values obtained in Tables 10.1 and 10.2 (Appendix E) were close to the ideal values of good fit, proposing that the devised size charts (Tables 7.19c & 7.20c – Appendix B) were quite accurate.

Tables 10.6 - 10.9¹³¹, below, demonstrate fit evaluation ratings in percentages, concerning the *bodice*, the *dress*, the *skirt* and the *trousers*, respectively, for both the **C₁R_RT_SS_{TL}** and **C₁R_RT_CS_T** groups, based on the *aggregate loss of fit*.

Table 10.6

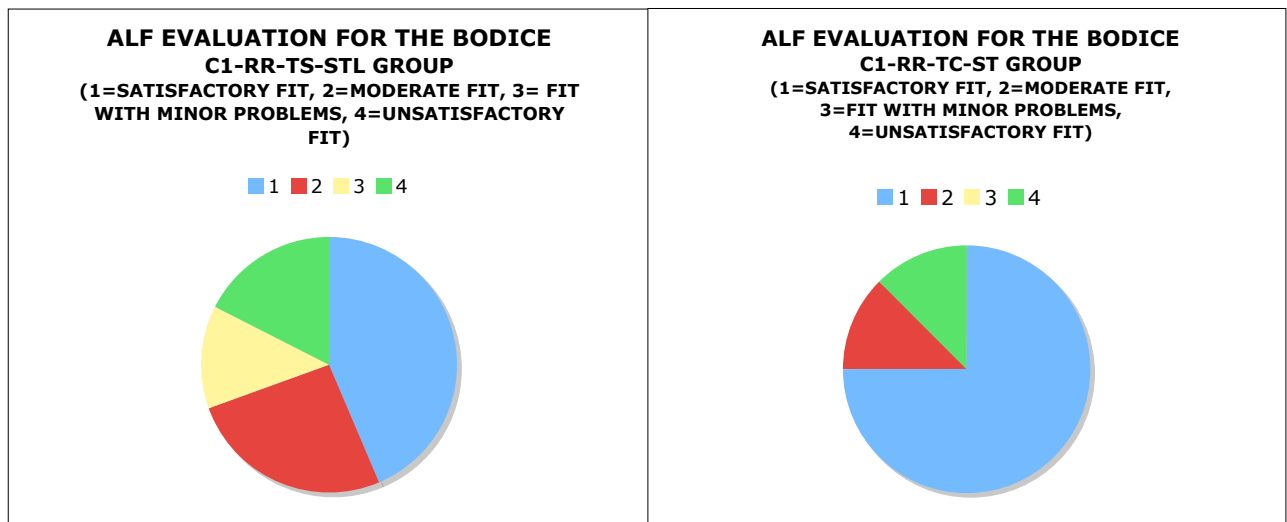


Table 10.6, above, depicts the fit evaluations for the **bodice**, comparing the fit ratings for the two most populated scoliotic groups. Hence, the *bodice block* for the **C₁R_RT_SS_{TL}** group was found to provide a *satisfactory fit* for nearly half of the sample (43.47%), a *moderate fit* for more than one quarter of the sample (26.08%), a fit with minor problems for 13.04% of the sample and an *unsatisfactory fit* for the remainder 17.39%. More

specifically, the '*bodice*' provided a *satisfactory fit* for 40% of the subjects belonging to size **S**, nearly two thirds of the subjects belonging to size **M** and 20% of the subjects belonging to size **L**.

On the other hand, the *bodice block* for the **C₁R_RT_CS_T** group was found to provide a *satisfactory fit* for three quarters of the sample (75%), a *moderate fit* for one eighth of the sample (12.5%) and an *unsatisfactory fit* for the remainder eighth of the sample (12.5%). More specifically, the '*bodice*' provided a *satisfactory fit* for two thirds of the subjects belonging to size **S**, three quarters of the subjects belonging to size **M** and for the only subject belonging to size **L** (100%).

Table 10.7

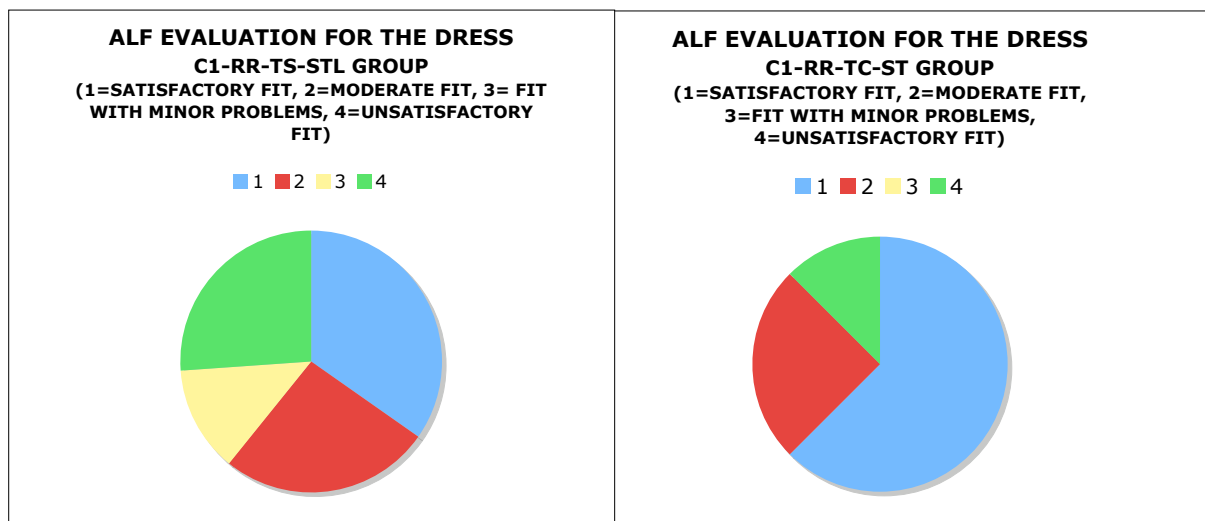


Table 10.7, above, indicates the fit evaluations for the **dress**, comparing the fit ratings for the two most populated scoliotic groups. Hence, the *dress block* for the **C₁R_RT_SS_{TL}** group was found to provide a *satisfactory fit* for more than one third of the sample (34.78%), a *moderate fit* for more than one quarter of the sample (26.08%), a fit with minor problems

¹³¹ Fit evaluation ratings' legends in Tables 10.6-10.9 are depicted in opposite scaling for high and low: i.e. 1 for *satisfactory*, 2 for *moderate*, 3 for *minor problems* and 4 for *unsatisfactory*, indicating the percentages,

for 13.04% of the sample and an *unsatisfactory fit* for more than one quarter of the sample (26.08%). More specifically, the 'dress' provided a *satisfactory fit* for 40% of the subjects belonging to size **S**, nearly half of the subjects (45.45%) belonging to size **M** and 20% of the subjects belonging to size **L**.

On the other hand, the *dress block* for the **C₁R_RT_CS_T** group was found to provide a *satisfactory fit* for nearly two thirds of the sample (62.5%), a *moderate fit* for exactly one quarter of the sample and an *unsatisfactory fit* for the remainder one eighth of the sample (12.5%). More specifically, the 'dress' provided a *satisfactory fit* for two thirds of the subjects belonging to size **S**, half of the subjects belonging to size **M** and for the only subject belonging to size **L** (100%).

Table 10.8

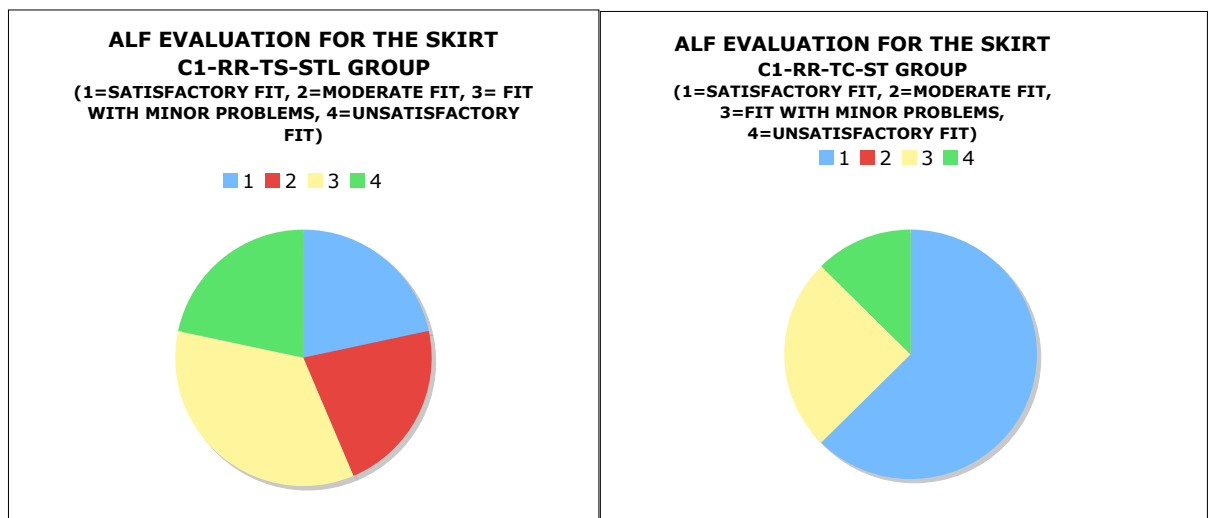


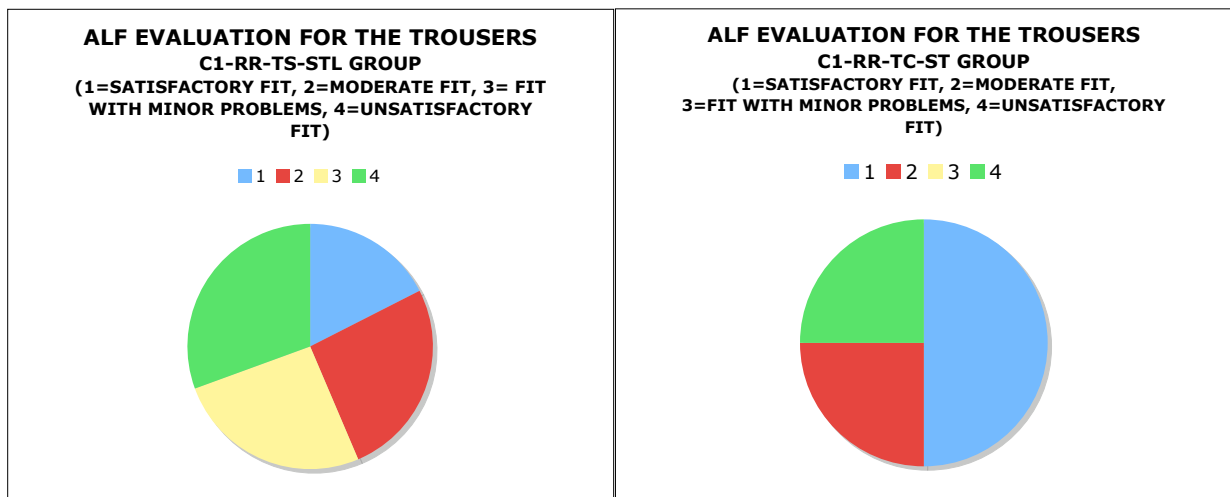
Table 10.8, above, depicts the fit evaluations for the **skirt**, comparing the fit ratings for the two most populated scoliotic groups. Hence, the *skirt block* for the **C₁R_RT_SS_{TL}** group was found to provide a *satisfactory fit*, a *moderate fit* and an *unsatisfactory fit* for equal divisions of the sample (21.73%), while the remainder one third of the sample (34.78%)

from highest to lowest, in sequential numbers (1,2,3,4)

represented a *fit with minor problems*. More specifically, the 'skirt' provided a *satisfactory fit* for 40% of the subjects belonging to size **S**, 18.18% of the subjects belonging to size **M** and 20% of the subjects belonging to size **L**.

On the other hand, the *skirt block* for the **C₁R_RT_CS_T** group was found to provide a *satisfactory fit* for nearly two thirds of the sample (62.5%), a *fit with minor problems* for one quarter of the sample (25%) and an *unsatisfactory fit* for the remainder one eighth of the sample (12.5%). More specifically, the 'skirt' provided a *satisfactory fit* for one third of the subjects belonging to size **S**, three quarters of the subjects belonging to size **M** and for the only subject belonging to size **L** (100%).

Table 10.9



Finally, Table 10.9, above, shows the fit evaluations for the **trousers**, comparing the fit ratings for the two most populated scoliotic groups. Hence, the *trouser block* for the **C₁R_RT_SS_{TL}** group was found to provide a *satisfactory fit* for 17.39% of the sample, a *moderate fit* for more than one quarter of the sample (26.08%), a fit with minor problems for another 26.08% of the sample and an *unsatisfactory fit* for nearly one third of the

sample (30.43%). More specifically, the 'trousers' provided a *satisfactory fit* for 20% of the subjects belonging to size **S** and 27.27% of the subjects belonging to size **L**.

On the other hand, the *trouser block* for the **C₁R_RT_CS_T** group was found to provide a *satisfactory fit* for exactly half of the sample, a *moderate fit* for one quarter of the sample and an *unsatisfactory fit* for the remainder quarter of the sample. More specifically, the 'trousers' provided a *satisfactory fit* for one third of the subjects belonging to size **S** (33.33%), half of the subjects belonging to size **M** (50%) and for the only subject belonging to size **L** (100%).

It is also interesting to note that the majority of the subjects belonging to the **C₁R_RT_SS_{TL}** group represented a *satisfactory fit* in the bodice and the dress, a fit with minor problems in the skirt and an *unsatisfactory fit* in the trousers, while the majority of the subjects belonging to the **C₁R_RT_CS_T** group represented a *satisfactory fit* in all the four different garment styles.

In general, concerning the **C₁R_RT_SS_{TL}** group, **the average fit rating for the bodice and the dress was found to be moderate, while it was found to have minor problems for the skirt and the trousers** (Table 10.1 – Appendix E), whereas concerning the **C₁R_RT_CS_T** group, **the average fit rating was found to be satisfactory for the bodice and moderate for the other three garment styles** (Table 10.2 – Appendix E).

Overall, it was quite interesting to compare the four different pattern categories (bodice, dress, skirt and trousers) in terms of fit, in order to determine the construction of only 'dress toiles' for the garment trials. The construction of seven differently sized dresses, based on the 'basic dress pattern blocks' designed for this research, would efficiently pinpoint any fit problems, in each size, not only concerning the upper, but also the lower torso.

Tables 10.10 - 10.13, below, illustrate how the two most common scoliotic groups (**C₁R_RT_SS_{TL}** and **C₁R_RT_CS_T**) populate a normal distribution curve, referring to the fit of the *bodice*, the *dress*, the *skirt* and the *trousers*, respectively.

To conclude, the sample's distribution curves referring to the fit of the bodice were normal and slightly skewed to the right, for both groups (Table 10.10), the curves of the dress and the skirt fit for the **C₁R_RT_CS_T** group (Tables 10.11 & 10.12) were also normal and slightly skewed to the right, while the curves of the dress, the skirt and the trouser fit for the **C₁R_RT_SS_{TL}** group (Tables 10.11, 10.12 & 10.13) were definitely skewed to the right. Finally, the curves of the trouser fit for the **C₁R_RT_CS_T** group, also demonstrated a distribution skewed to the right (Table 10.13).

The fact that all the distribution curves (Tables 10.10-10.13) were skewed to the right (positively skewed), implicates that the *mean* values (μ) of the aggregate loss are on the right side of the *peak* values. In such cases, the *mean* value is greater than the *median* value, reflecting the fact that the mean is sensitive to each score in the distribution and is subject to large shifts when the sample is small and contains extreme scores (outliers) – which is perfectly justified, given the small data sample for this research.

Table 10.10

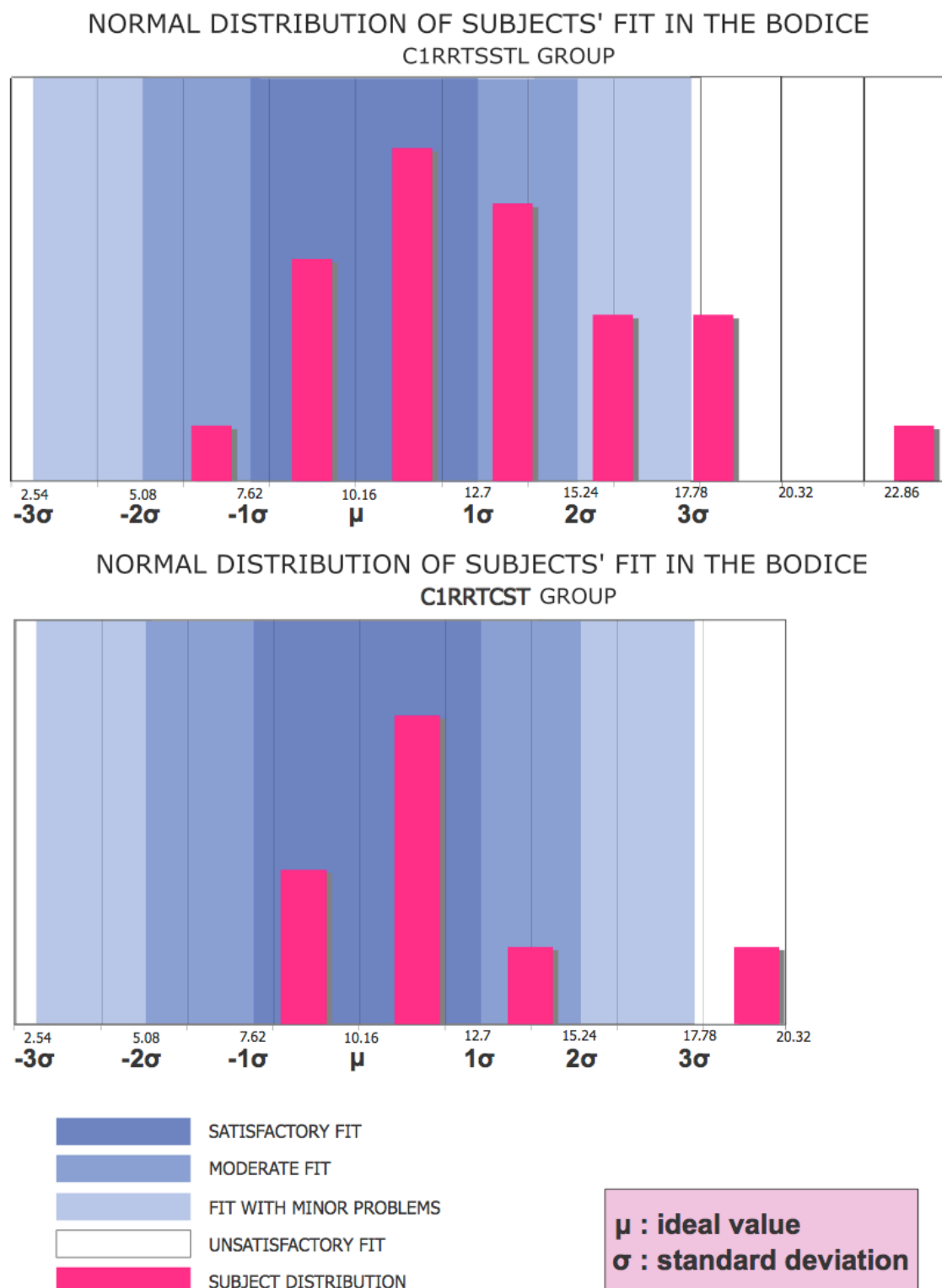


Table 10.11

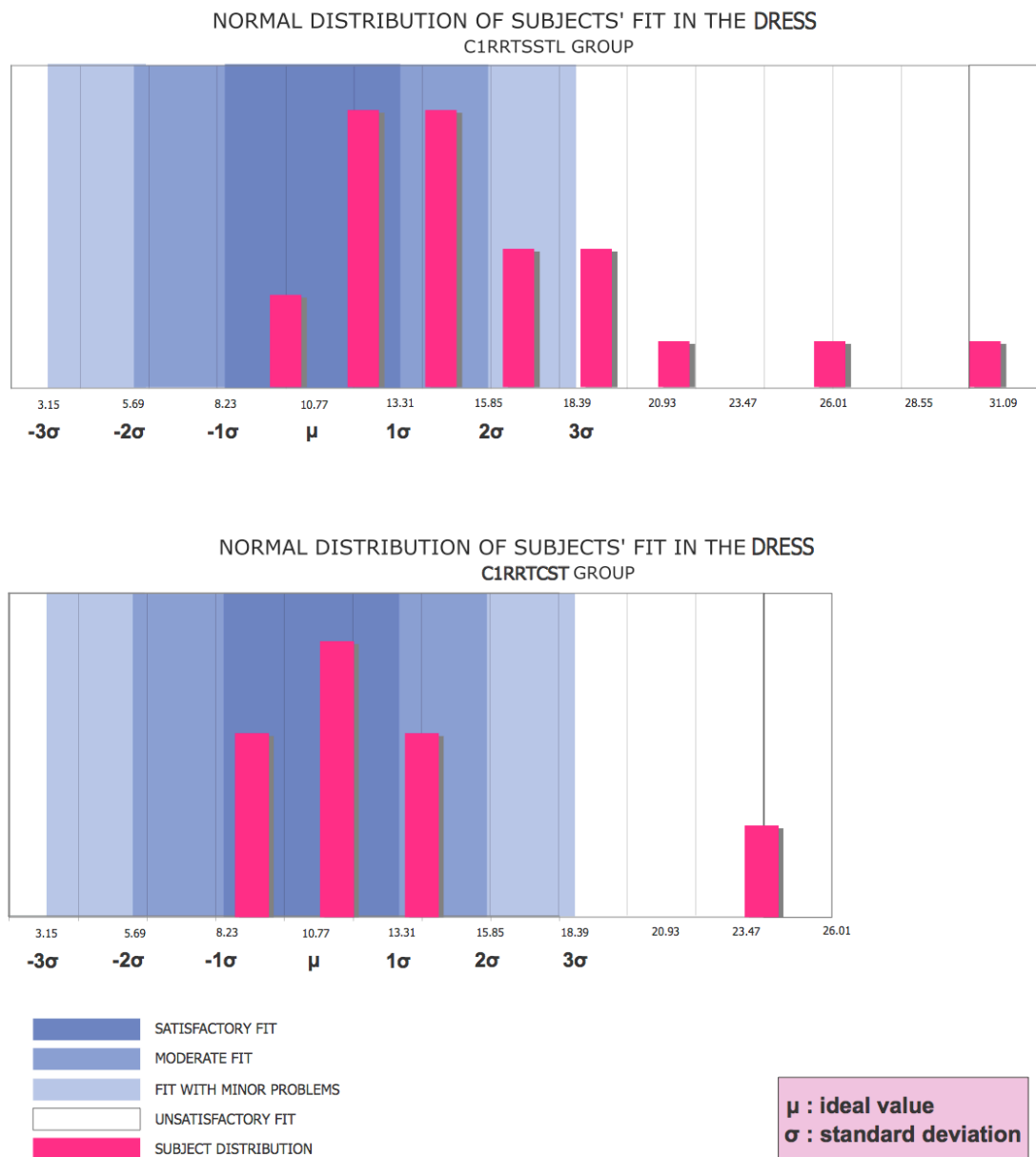


Table 10.12

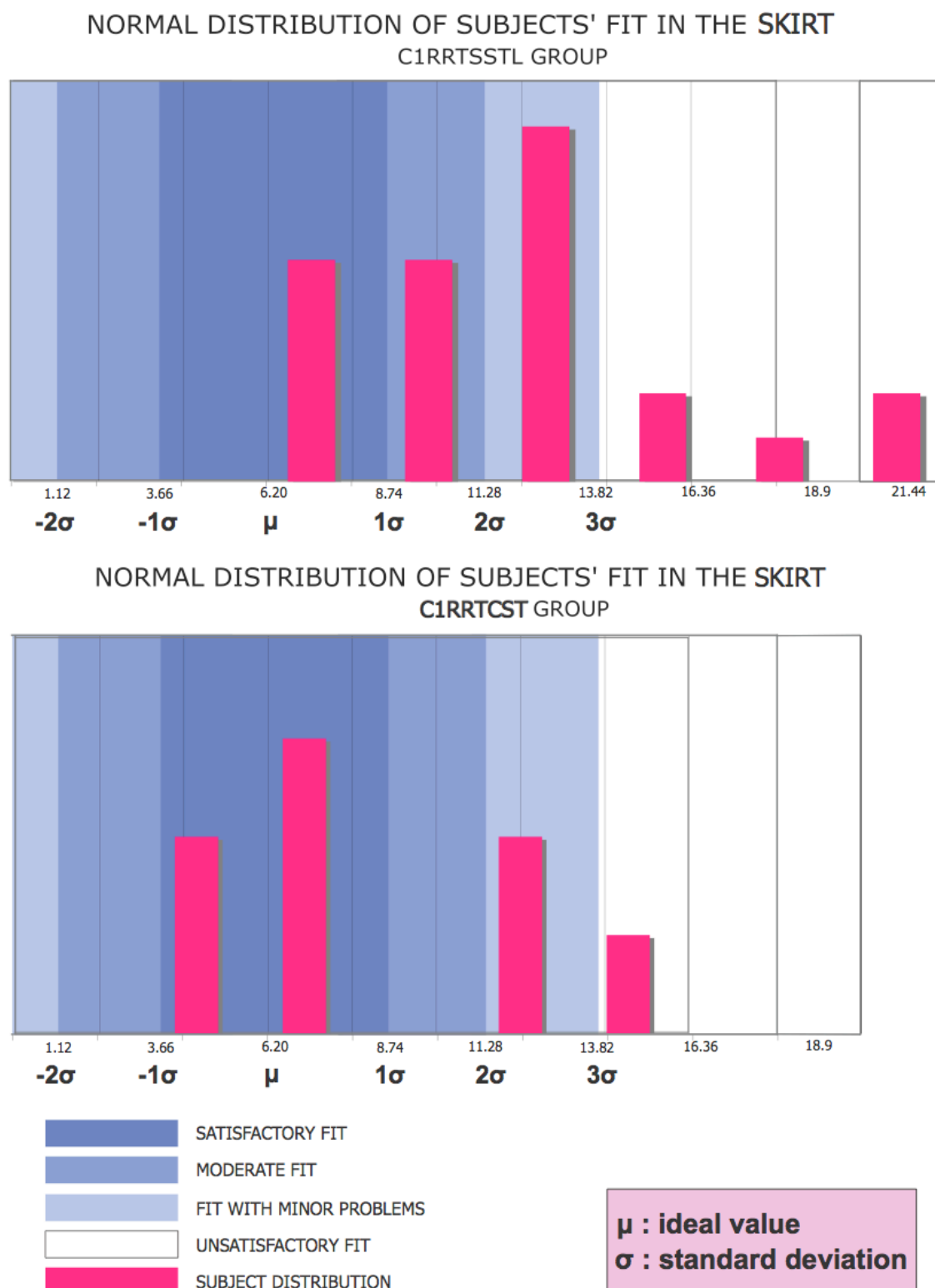
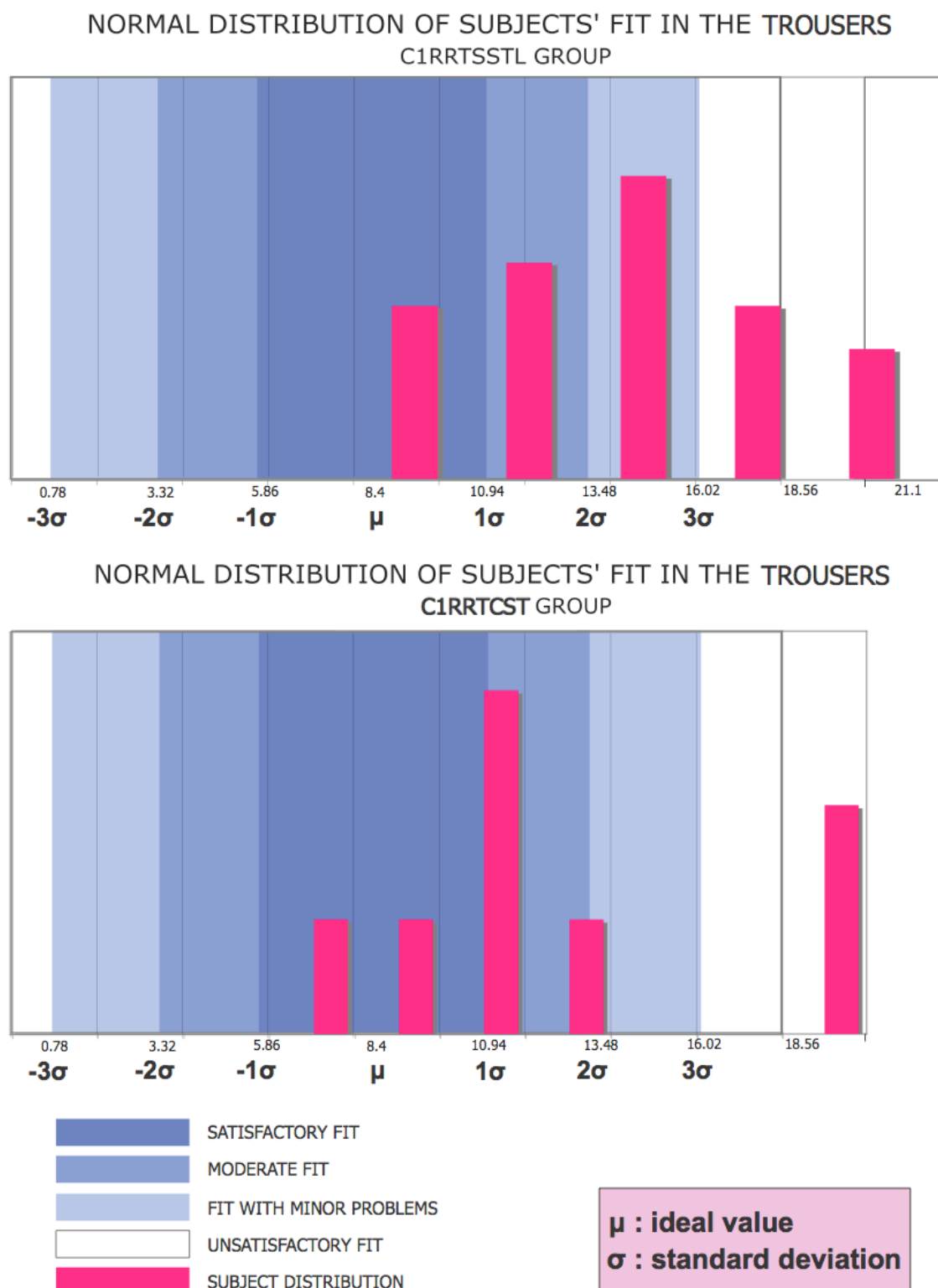


Table 10.13



Notwithstanding, when initially developing a sizing system with the help of an automated alteration system, such as the '*PolyPatternM2M*' software, the process should be tested and proven repeatedly, using a variety of fit models with diverse fit problems. In this way, successful implementation is ensured and hidden errors can be found.

Therefore, once the *Aggregate Loss of Fit* was calculated, trial garments (toiles) were sewn, based on the devised '*dress pattern blocks*' for this study and fitting trials were conducted using live fit models (from the scoliotic sample), thereby confirming the proposed size charts (Tables 7.29 & 7.30, Chapter 7.6.3:297-298). These wearer trials involved the construction of 7 different dresses – garments covering the upper, as well as the lower torso – based on the '*Median Basic*' dress pattern blocks for the two most populated scoliotic groups, via the '*PolyPatternM2M*' software.

10.2. Visual Fit Evaluations based on Garment Trials

Seven dresses - in sizes **S**, **M**, **L** & **XL** for the **C₁R_RT_SS_{TL}** group and in sizes **S**, **M** & **L** for the **C₁R_RT_CS_T** group – were sewn and tested on 14 subjects, randomly selected by lottery, in order to obtain unbiased findings (Appendix E) when evaluating the dresses' fit on live models. All the toiles were made of the same fabric (100% cotton woven fabric) and made up using the *Median basic pattern blocks* for the *dress*, in each body size. Hence, wearer trials were mainly done for 2 reasons:

- The **first** was to determine whether toiles made up using pattern blocks based on median body measurements of the specific scoliotic group the subjects were classified in, according to their personal body measurements, provided a good fit for each subject belonging to that group, separately.
- The **second** was to consider whether there were any alterations or adjustments needed to be done to each *median basic pattern block*, or whether the blocks

could be kept intact. In the case of pattern alteration involving minor adaptations or no adaptations at all, a pattern-making approach for clothing asymmetric bodies, could be potentially introduced in a more customised, than bespoke level.

Data analyses were conducted using both visual and statistical analyses. The objective was to identify visual clues concerning the level of fit or ill-fit within participants, belonging to the same size group, wearing the same size garment. Overall fit satisfaction was rated on a 4-point scale (*satisfactory, moderate, minor problems* and *unsatisfactory*), based on stress folds and other visual indications of misfit.

Fabric is a key element in fulfilling the desired function for which a garment is being designed, while the properties of the material selected, as the behaviour and the characteristics of a specific fabric, determine the dimensions of the final block. Each fabric type has its own unique properties and characteristics, regarding which one can achieve the desired comfort, fit and functionality. Thus, the toiles were all made up in natural calico, a 100% medium-weight (150-200gr/m²) cotton woven fabric, in neutral colour. Calico is not the most flattering fabric, due to the fact that it doesn't mould to the body. Nevertheless, it was selected deliberately for the wearer trials because it is the most common fabric used for making up toiles: as it is inexpensive, one can mark alterations and see the grain-line easily on it, while it is good for analyzing the pattern alignment to the body. Moreover, calico toiles are used as a standard way of assessing the fit of a garment throughout the fashion industry.

Great precision was required at all stages of marking, cutting and construction of the toiles, which were sewn in a way that the garment fit could be determined and evaluated, as accurately as possible, by the same sample machinist, in order to obtain as much consistency as possible, and eliminate any errors related to the human factor.

The desired functionality of a garment and the constraints imposed by function and

aesthetics, guide and define the selection of openings and closure, trims, seam types and seam finishes. For this purpose, all the toiles were made up using 1cm seam allowance and all the seams were 'finished' with *picot stitch* in the inside. Moreover, invisible zips sewn along the left side-seam (from armpit to hip) were used in all seven dresses, in order to facilitate the garment opening. The aim was to avoid having a seam at the centre back because it wouldn't be straight and, consequently, not aesthetically pleasing due to rotation and bending of the spine towards one side.

In addition, all the dresses had a facing around the neckline, with a small slit (5cm) at the centre back, in order to facilitate the wear of the garment since there was no zip at the back. In addition, the dresses were developed without a waistline seam, with fullness controlled by two front bust darts starting at mid-shoulder, two front and two back waist darts, one back shoulder dart at the left mid-shoulder and one right back mid-scyce dart for the prominent scoliotic curve. Ease amounts were consistent across the size range for patterns derived directly via the *PolyPatternM2M* software, following the ease amounts incorporated initially in the W. Aldrich pattern blocks for **UK size 12**, which are also used in industry.

Fit testing of the garment sizing system developed for the two most populated groups of females with scoliosis, was done by testing the 'dress' block, in each size, on one or more participants, representing the targeted groupings as a whole (Ashdown, Loker, Schoenfelder & Lyman-Clark, 2004:1-12). The participants were asked to remain in their regular underwear or body shaping garments and to wear the toiles on top. Participants' ages and dates of fit trials were recorded, while certain key dimension measurements were re-taken manually before both wearer trials, so that measurements could be compared with the measurements of their first measuring in the hospital setting, for more accurate results (Appendix D). Moreover, participants were asked to wear their shoes on for the fit tests.

Each participant was given the dress toile attributed to the assigned size she was classified in, while she was asked to raise and flex her arms, assuming a driving position, in order to check the acceptability of fit in the bust and chest area in such an active position (Petrova & Ashdown, 2012:274). Once a toile was worn, front and back photographs of the participant wearing the garment were taken in standard conditions, which ensured equal presentation of the garments worn by different participants. The participant was asked to stand in her usual relaxed posture, with her hands brought slightly away from the body, in front of a dark-coloured wall (in contrast to the light-coloured toiles) in the researcher's studio, 1.5m behind a digital camera (Pentax – Optio S4) stationed on a tripod.

Generally, the methods of fit evaluation are qualitative, involving the subjective opinion of humans. Such methods include direct observation and description, participants' responses and expert evaluations and ratings (Watkins, 1995). Therefore, in order to best evaluate the results of each wearer trial, the researcher evaluated each dress, in each size, separately, after taking into account each participant's suggestions and remarks on the dress they had worn, i.e. which parts or areas should be altered, in order to provide better fit, comfort, tolerance, movement and outward appearance.

A convenience sample of 14 participants, selected randomly, from the already measured adolescents girls, with right thoraco-lumbar and right thoracic scoliosis, were recruited as fit test participants, exhibiting moderate variation in body proportions, shape and posture, within the same size. At this point, it is interesting to note that this evaluation enabled the subjects, who **had no prior specialists' fit training**, to comment on a few specific areas of the garment-toiles, in addition to the overall feeling, fit, outward appearance and comfort of the toiles (Appendices D1 - D).

It is very important to assess wearers' fit evaluations in a fit test of this nature, however, as the participants in this research project were not professional fit models, having no explicit knowledge of good fit, their responses focused on whether garments felt very tight or very loose on them. Since the custom fit process can only provide a theoretically perfect fit based on individual measurements and standard ease requirements, without considering individual fit preferences, the participants' responses were different, due to their own fit perceptions and preferences.

The 14 participants (9 for the **C₁R_RT_SS_{TL}** group and 5 for the **C₁R_RT_CS_T** group) tried the dresses and commented on their fit, while they were asked to fill out an evaluation form, assessing the fit of each dress in zones – evaluating each garment zone, separately, on a 4-point scale, ranging from 1 (unsatisfactory) to 4 (satisfactory). The overall fit satisfaction was calculated, on the same 4-point scale, obtaining the average from the different garment zones' evaluation.

Evaluation forms consisted of 38 questions, a quite high number, in order to generate a concise amount of evaluation data. The evaluation sheets used were as objective as they could be, for evaluating the toiles. The questions were 'built-in' in such a way, that they could provide the most unbiased and reliable findings. Question 33 (Appendix D1), for example, intended to provide an answer on what adaptations should be made to each different zone (area) of the dress, in order to obtain the best garment fit. Emphasis was given to adaptations that should be made on different zones of the garments (i.e. shoulder, bust, waist, hips, etc) that conformed to body-areas, which needed attention and their results. Furthermore, if the evaluation i.e. of the overall feeling of the test toile were marked as '*minor problems*', the following question would demand the explanation for this statement, in order to examine the cause. This was, also, one of the main reasons that the wearer trial was not anonymous. It was crucial for the researcher to be

able to analyse the answers of each subject, in relation to their scoliotic curve degrees and the size group that they belonged.

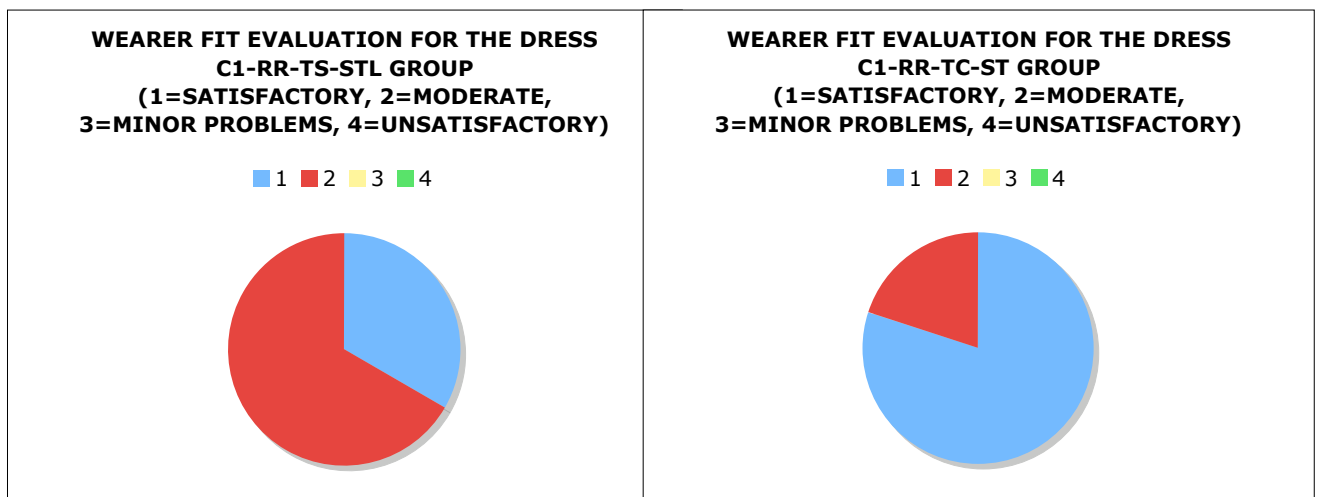
A standard framework for assessing fit was developed based on the **five principles of fit: ease, line, grain, balance and set** (Erwin, Kinchen & Peters, 1979). Hence, garment fit, in this research, was evaluated based on the following **nine fit criteria** (Joseph-Armstrong, 2000; Erwin, Kinchen & Peters, 1979; Liechty, Pottberg & Rasband, 1992):

- The garment should have **adequate amount of ease** to allow **for movement and provide comfort** to the wearer
- **The line of the garment should follow the body contours**
- The **garment should not have any undesirable pulls, creases, or shifting towards one side, or strains at the shoulders, bust, waist and hips**
- **The grain should be parallel to the centre front and centre back** of the garment, which should align with the body centre
- The **shoulder seam should be centered on the shoulder**
- The **armscyes should fit smoothly around the arms**
- There **shouldn't be any stress or gapping at the neckline**
- The **waist level should align with body waist**
- The skirt or dress should hang straight from hip to hem, with **hem parallel to floor**

10.2.1. Results

Table 10.14¹³², below, demonstrates the fit evaluations for the **dress**, comparing the fit ratings for the two most populated scoliotic groups (**C₁R_RT_SS_{TL}** and **C₁R_RT_CS_T**), after the wearer trials.

Table 10.14



On the one hand, the *dress block* for the **C₁R_RT_CS_T** group was found to provide a *satisfactory fit* for four out of five participants, and a *moderate fit* for only one out of five. More specifically, the ‘*dress*’ provided a *satisfactory fit* for all the subjects participating in the wearer trial that belonged to sizes **S** and **M**.

On the other hand, the *dress block* for the **C₁R_RT_SS_{TL}** group was found to provide a *satisfactory fit* for one third of the sample ($n=3$ out of 9 participants), taking part in the wearer trial, while the remainder two thirds ($n=6$ out of 9 participants), of the same sample, represented a *moderate fit* in the ‘*dress*’. More specifically, the ‘*dress*’ provided

¹³² Fit evaluation ratings’ legends in Table 10.14 are depicted in opposite scaling for high and low: i.e. 1 for *satisfactory*, 2 for *moderate*, 3 for *minor problems* and 4 for *unsatisfactory*, indicating the percentages, from highest to lowest, in sequential numbers (1,2,3,4)

a *satisfactory fit* to all the subjects participating in the wearer trial that belonged to size **S**, as well as to one quarter of the subjects ($n=1$ out of 4 participants) belonging to size **M**.

A general tendency, based on findings from both scoliotic groups, was that none of the subjects, participating in the wearer trial, represented a *fit with minor problems*, or an *unsatisfactory fit*, in any of the different sizes of the 'dress' toile, in both groups. Fit was rated with a numeric assessment between *moderate* or *satisfactory*, for each subject separately (Appendix E). In detail, the dress toiles provided a *satisfactory fit*, for all the subjects participating in the wearer trial, in sizes **S** and **M** of the **C₁R_RT_CS_T** group, while only in size **S** of the **C₁R_RT_SS_{TL}** group.

In conclusion, garment fit rated based on the researcher's own visual evaluations, taking into account the participants' comments, found the average fit of the 'dress' toile for the **C₁R_RT_CS_T** group *satisfactory* (Table 10.20 – Appendix E), whereas the average fit of the 'dress' toile for the **C₁R_RT_SS_{TL}** group *moderate* (Table 10.19 – Appendix E).

10.3. Fit Analysis Findings

Both qualitative and quantitative analyses were used to interpret garment fit, allowing a holistic interpretation.

10.3.1. Qualitative (visual) analysis

Qualitative analysis included visual assessment of garments in relation to wearers' bodies. When apparel sizing systems are developed using only linear data and proportional grading, one can see how difficult it is to provide acceptable fit for all variations of women's' bodies. For example, three out of four participants in size **M**, wearing the same 'dress' toile, derived from the **AVGM-Dress-C₁R_RT_SS_{TL}** (dress pattern

block derived from Median Measurements for size **M**) represented a *moderate* fit in the dress, while only one out of four represented a *satisfactory* fit (Table 10.19 - Appendix E). The stress folds and corresponding body curves and bulges viewed without the dress toile informed the analysis of dress fit. Additionally, wrinkles that indicate ill-fit in the dress can be analyzed using knowledge of the underlying body shape, registered in the Subjects' Measurement Chart (Appendix B).

Visual analysis fit ratings were assessed, using a *database form* in *zones*, related to different body areas, in Microsoft Excel (14 Separate Subjects' Fit Evaluations – Appendix E). Visual analysis offered a qualitative assessment of fit, typical of fit sessions, except with a larger range. Fit assessments were performed for 14 participants in seven different size categories – 9 participants for the **C₁R_RT_SS_{TL}** group (2 in size **S**, 4 in size **M**, 2 in size **L** and 1 in size **XL**) and 5 participants for the **C₁R_RT_CS_T** group (2 in size **S**, 2 in size **M**, and 1 in size **L**). The participants' fit ratings in each zone-cell were averaged in the end, in order to provide the overall fit assessment of the garment for each participant. Visual analysis in zones also aided in validating the accuracy of the fit ratings, by being able to compare separately the researcher's own fit evaluations, during the wearer trial, to the results of the 'Aggregate Loss of Fit' (Tables 10.19 & 10.20 – Appendix E).

Two approaches were explored using these ratings to investigate the relationship between body and garment, or ill-fit, in order to find predictive strategies that could be used to identify acceptable fit: analysis of fit ratings by size and analysis of fit ratings based on ease values, such as wear comfort, ease of movement, tolerance and outward appearance.

Front and Back View photos, depicting the subjects wearing the toiles, helped the researcher identify the most problematic fit areas around *the neck, shoulders, scyes,*

sleeves, bust, back, waist, hips and length at hem, while more than half of ill-fit analyses pointed to the scye, waist and mid-back as the critical fit areas with the most problems in achieving a *satisfactory* fit for the test dresses. The participant evaluation forms (Appendix D1 – D) were designed to measure the participants' perception of the toiles' fit at various body locations, as well as of overall garment fit.

Results from both scoliotic groups showed that the majority of the participants ($n = 12$ out of 14 participants) did not perceive any fit problems in the bust and hip areas or front length, while almost all ($n = 13$ out of 14 participants) indicated minor fit problems around the armholes. Eight out of fourteen subjects did not perceive any problems with the fit of the dress at the shoulder or neck area, while only five did not report any fit problems in the waist area and only three in the mid-back area.

Overall, almost two thirds of the sample ($n = 9$ out of 14 participants) found the overall dress fit *satisfactory*, whereas the remainder one third ($n = 5$) found the overall dress fit *moderate*.

The process of fit rating based on visual evaluation and size categorization identified problems within some sizes and not others. The results pointed out problems with non-proportional grading assumptions that underlie most pattern development systems (Loker *et al*, 2005:1-15), while it seemed clear that there were fit issues, specific to particular sizes of each group (Appendix E):

C₁R_RT_SS_{TL} group

The '*dress*' toile for the **C₁R_RT_SS_{TL}** group was found to be rather large and low around the *armscyes*, in all sizes (**S**, **M**, **L** and **XL**) and quite wide at the *shoulders*, mostly in sizes **S** and **M** and less in size **L**. The *sleeves* were found to be quite wide in sizes **S**, **L** and **XL**, whereas rather short in size **M** (Table 10.15).

In addition, the fit of the 'dress' toile was found to be *unsatisfactory* around the *neck* area in the larger sizes (**L** and **XL**), while the *bust* appeared to be too large, only in size **XL**. The *mid-back* and the *waist* areas were found to be either too wide or too tight for eight out of nine participants (in all sizes), while certain participants in sizes **S** and **L** complained about the hip girth of the toile being quite tight around their hips. Overall, the length of the dress provided a fit with minor problems in half of the participants ($n = 2$ out of 4) in size **M**.

Pattern Adaptations

The above findings lead to the following 4 pattern alterations for the C₁R_RT_SS_{TL} group:

- Taking up both right / left *armscyes* by 1.5cm, in all sizes (**S**, **M**, **L** and **XL**)
- Taking in the shoulder length (both right / left) by 1.5cm in size **S**, 1cm in size **M** and 0.5cm in size **L**
- Taking in the chest width by 1cm on both sides, in size **L** and by 1.5cm in size **XL**
- Taking out the hip width by 0.5cm on each side (right / left) front and back, in all sizes (**S**, **M**, **L** and **XL**)

Table 10.15



S58S-Dress-C1-RR-TS-STL	
WEARER TRIAL EVALUATIONS (11/12/2013)	
THE RESEARCHER'S EVALUATIONS BASED ON THE SUBJECTS' COMMENTS	
NECK: -	4
SHOULDERS: -	4
SCYE (ARMHOLE AREA): A BIT WIDE & LOW	3
SLEEVES: A BIT WIDE	3
BUST: -	4
MID BACK: A BIT TIGHT	3
WAIST: A BIT TIGHT	3
HIPS: -	4
LENGTH: -	4
AVERAGE RATING OF FIT: (SATISFACTORY)	4

S59M-Dress-C1-RR-TS-STL	
WEARER TRIAL EVALUATIONS (11/12/2013)	
THE RESEARCHER'S EVALUATIONS BASED ON THE SUBJECTS' COMMENTS	
NECK: -	4
SHOULDERS: -	4
SCYE (ARMHOLE AREA): A BIT LOW	3
SLEEVES: A BIT SHORT	3
BUST: -	4
MID BACK: -	4
WAIST: -	4
HIPS: -	4
LENGTH: -	4
AVERAGE RATING OF FIT: (SATISFACTORY)	4

S19L-Dress-C1-RR-TS-STL	
WEARER TRIAL EVALUATIONS (8/1/2014)	
THE RESEARCHER'S EVALUATIONS BASED ON THE SUBJECTS' COMMENTS	
NECK: A BIT 'LIFTED' UPWARDS ON THE LEFT SIDE	3
SHOULDERS: -	4
SCYE (ARMHOLE AREA): -	4
SLEEVES: -	4
BUST: -	4
MID BACK: LARGE	3
WAIST: TOO LARGE	2
HIPS: TIGHT	3
LENGTH: -	4
AVERAGE RATING OF FIT: (MODERATE)	3

S12XL-Dress-C1-RR-TS-STL	
WEARER TRIAL EVALUATIONS (7/12/2013)	
THE RESEARCHER'S EVALUATIONS BASED ON THE SUBJECTS' COMMENTS	
NECK: TOO WIDE AT THE FRONT	1
SHOULDERS: -	4
SCYE (ARMHOLE AREA): A BIT LOW	3
SLEEVES: A BIT WIDE	3
BUST: TOO WIDE	2
MID BACK: TOO WIDE	3
WAIST: -	4
HIPS: -	4
LENGTH: -	4
AVERAGE RATING OF FIT: (MODERATE)	3

C₁R_RT_CS_T group

The 'dress' toile for the **C₁R_RT_CS_T** group was found to be rather large and low around the *armscyes*, in all sizes (**S**, **M** and **L**) and quite wide at the *shoulders*, only in size **S**. The *sleeves* were found to be quite short and wide, also in size **S** (Table 10.16).

In addition, the fit of the 'dress' toile was found to be *unsatisfactory* around the *neck* area in the larger sizes (**M** and **L**), while the *bust* appeared to be a bit large, only in size **M**.

The *mid-back* and the *waist* areas were found to be either too wide or too tight for half of the participants in sizes **S** and **M**, and rather tight for the one participant representing size **L**.

Pattern Adaptations

The above findings lead to the following 3 pattern alterations for the C₁R_RT_CS_T group:

- Taking up both right / left *armscyes* by 1.5cm, in all sizes (**S**, **M** and **L**)
- Taking in the shoulder length (both right / left) by 1cm in size **S**
- Taking in the chest width by 1cm on both sides, in sizes **M** and **L**

On the one hand, pattern alterations, for both groups, involved minor adjustments in the upper torso, implying that the devised patterns could provide an acceptable fit to all the subjects belonging to the two most populated scoliotic groups, after taking into account these adjustments. On the other hand, Rasband and Liechty (2006:64) point out that *neckline* and *shoulder* alterations 'set up a chain reaction of other fitting problems' and strongly advise against purchasing garments that require these alterations, or multiple alterations, as they will 'likely never fit properly'.

Table 10.16



S63S-Dress-C1-RR-TC-ST

S15M-Dress-C1-RR-TC-ST

S18L-Dress-C1-RR-TC-ST

S63S-Dress-C1-RR-TC-ST	
WEARER TRIAL EVALUATIONS (18/12/2013)	
THE RESEARCHER'S EVALUATIONS BASED ON THE SUBJECTS' COMMENTS	
NECK: -	4
SHOULDERS: A BIT WIDE	3
SCYE (ARMHOLE AREA): A BIT WIDE & LOW	3
SLEEVES: A BIT SHORT & WIDE	3
BUST: -	4
MID BACK: A BIT WIDE	3
WAIST: -	4
HIPS: -	4
LENGTH: -	4
AVERAGE RATING OF FIT: (SATISFACTORY)	4

S15M-Dress-C1-RR-TC-ST	
WEARER TRIAL EVALUATIONS (10/1/2014)	
THE RESEARCHER'S EVALUATIONS BASED ON THE SUBJECTS' COMMENTS	
NECK: -	4
SHOULDERS: -	4
SCYE (ARMHOLE AREA): A BIT TIGHT	3
SLEEVES: A BIT SHORT	3
BUST: -	4
MID BACK: A BIT TIGHT	3
WAIST: -	4
HIPS: -	4
LENGTH: -	4
AVERAGE RATING OF FIT: (SATISFACTORY)	4

S18L-Dress-C1-RR-TC-ST	
WEARER TRIAL EVALUATIONS (28/12/2013)	
THE RESEARCHER'S EVALUATIONS BASED ON THE SUBJECTS' COMMENTS	
NECK: 'LIFTED' UPWARDS	2
SHOULDERS: -	4
SCYE (ARMHOLE AREA): A BIT WIDE & LOW	3
SLEEVES: -	4
BUST: -	4
MID BACK: A BIT TIGHT	3
WAIST: A BIT TIGHT	3
HIPS: TIGHT AT THE HIGH-HIP AREA	3
LENGTH: -	4
AVERAGE RATING OF FIT: (MODERATE)	3

According to ASTM¹³³, grading of the *neck* and *shoulder* areas is inter-related, the *shoulder length* measurement being related to the *half-shoulder tip width*, while it increases variably by *horizontal neck width* and *vertical shoulder slope* grade intervals (x, y coordinates). ASTM provides a *neck base girth* measurement for each size that results in a total girth increase of 1.25cm per size, although the final neck girth is actually dependent on the shape of the neck curve. Excess front neck girth, thus, could be transferred to the *bust darts*.

The visual analysis of the pattern outlines indicated that the shoulders did not exhibit a regular pattern of growth (Figure 9.18), a fact that established the findings of an earlier study by Bye *et al.* (2008:87), whereby the shoulders were also not graded regularly. Moreover, this irregular shoulder pattern growth, between sizes, was also different for left and right side (due to scoliosis), resulting in shoulder asymmetry on each pattern. Given that only 17.24% of the total number of adjustments for the evaluated participants, in this wearer trial, were in the *neck* and *shoulder* areas, it was concluded that **shape-to-fit patternmaking practices, of this kind, resulted in pattern profiles that provided an improved fit across the size range of the specific target group.**

10.3.2. Quantitative (statistical) analysis

To determine whether the fit measured in a subjective fit evaluation (researcher's evaluation based on participants' responses) is accurate or not, the findings based on such criteria should be combined with an objective method (aggregate loss of fit), by

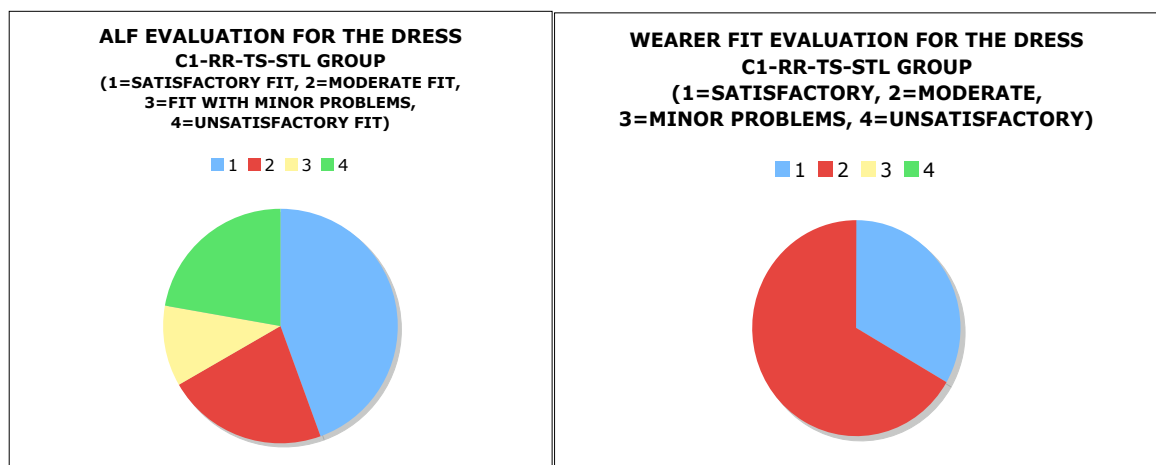
¹³³ <http://www.astm.org/Standards/> (Accessed 18th May 2011)

matching the data of the two methods. Hence, the *wearer trials' evaluations* were compared with the *'aggregate loss of fit'* results.

On the one hand, Table 10.17¹³⁴, below, indicates that according to the *'aggregate loss of fit'* findings, the *'dress block'* for the **C₁R_RT_SS_{TL}** group sample ($n = 9$) was found to provide a *satisfactory fit* for four subjects, a *moderate fit* for two subjects, a *fit with minor problems* for one subject and an *unsatisfactory fit* for another two.

On the other hand, according to the *'wearer trial'* fit ratings, the same *'dress block'* ($n = 9$) was found to provide a *satisfactory fit* for three subjects, while the remaining six represented a *moderate fit* in the *'dress'*.

Table 10.17

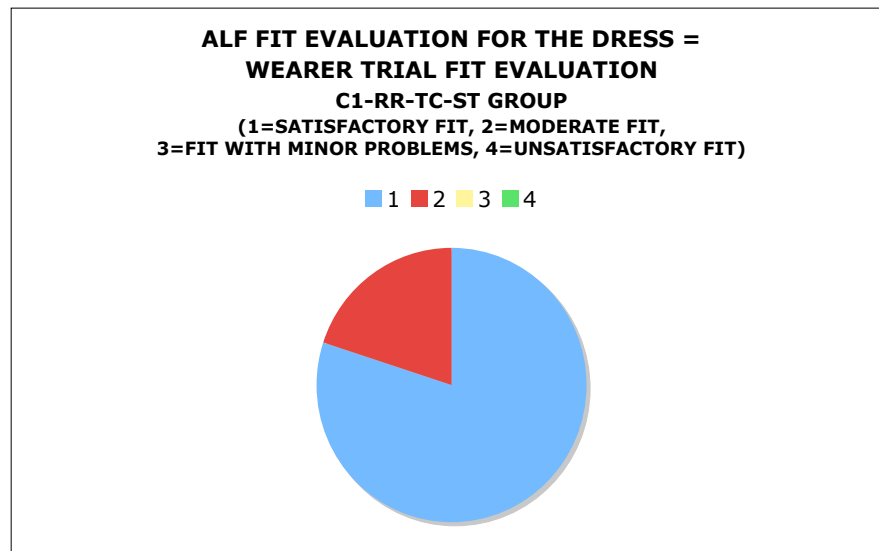


In addition, Table 10.18, below, indicates that, according to both the *'aggregate loss of fit'* findings and the *'wearer trial'* fit ratings, the *'dress block'* for the **C₁R_RT_CS_T** group sample ($n = 5$) was found to provide a *satisfactory fit* for the majority of the sample ($n = 4$), while the remainder one subject represented a *moderate fit* in the *'dress'*.

¹³⁴ Fit evaluation ratings' legends in Tables 10.12 & 10.13 are depicted in opposite scaling for high and low: i.e. 1 for *satisfactory*, 2 for *moderate*, 3 for *minor problems* and 4 for *unsatisfactory*, indicating the percentages, from highest to lowest, in sequential numbers (1,2,3,4)

At this point, it is interesting to note that findings, based on both the subjective and the objective method, were the same for the **C₁R_RT_CS_T** group sample ($n=5$).

Table 10.18



In conclusion, the average numeric rating of the **C₁R_RT_SS_{TL}** dress fit, tried on 9 participants, was found to be *moderate* (3), while the average numeric rating of the **C₁R_RT_CS_T** dress fit, tried on 5 participants, was found to be *satisfactory* (4) (Tables 10.19 & 10.20, below and in Appendix E).

Table 10.19: C₁R_RT_SS_{TL} Dress fit

CODE	12	16	20
S41S	80.00	71.00	93.00
S58S	83.50	68.00	93.50
Assigned (S)	82.00	67.00	92.50
S32M	91.00	67.00	102.00
S38M	90.50	79.50	102.00
S57M	90.50	76.00	93.00
S59M	94.00	80.00	101.00
Assigned (M)	89.00	74.00	101.00
S19L	88.00	74.00	112.00
S49L	88.50	75.00	109.00
Assigned (L)	96.00	81.00	109.50
S12XL	110.50	90.50	106.00
Assigned (XL)	103.00	88.00	118.00
DRESS			
Aggregate Loss of Fit - S41S	4	Wearer Trial Fit Evaluation- S41S	4
Aggregate Loss of Fit - S58S	3	Wearer Trial Fit Evaluation- S58S	4
Aggregate Loss of Fit - S32M	1	Wearer Trial Fit Evaluation- S32M	3
Aggregate Loss of Fit - S38M	4	Wearer Trial Fit Evaluation- S38M	3
Aggregate Loss of Fit - S57M	3	Wearer Trial Fit Evaluation- S57M	3
Aggregate Loss of Fit - S59M	4	Wearer Trial Fit Evaluation- S59M	4
Aggregate Loss of Fit S19L	2	Wearer Trial Fit Evaluation- S19L	3
Aggregate Loss of Fit S49L	4	Wearer Trial Fit Evaluation- S49L	3
Aggregate Loss of Fit S12XL	1	Wearer Trial Fit Evaluation- S12XL	3
Average Fit Rating (ALF)	3	Average Fit Rating (WTE)	3

Table 10.20: C₁R_RT_CS_T Dress fit

CODE	12	16	20
S29S	73	61	84
S63S	81	69.5	95
Assigned (S)	79.75	64.25	88.25
S10M	86	64.5	93
S15M	92.5	75	101
Assigned (M)	86.00	69.75	95.50
S18L	90.5	73.5	106.5
Assigned (L)	92.25	75.25	102.75
DRESS			
Aggregate Loss of Fit - S29S	4	Wearer Trial Fit Evaluation- S29S	4
Aggregate Loss of Fit - S63S	4	Wearer Trial Fit Evaluation- S63S	4
Aggregate Loss of Fit - S10M	4	Wearer Trial Fit Evaluation- S10M	4
Aggregate Loss of Fit - S15M	3	Wearer Trial Fit Evaluation- S15M	4
Aggregate Loss of Fit - S18L	4	Wearer Trial Fit Evaluation- S18L	3
Average Fit Rating (ALF)	4	Average Fit Rating (WTE)	4

10.4. Assessment Conclusions

According to the mathematical formula calculating the aggregate loss of fit, findings from both groups' data analysis demonstrated a general tendency of the garments, common in all four different garment-pattern styles, to provide a *satisfactory fit* for a larger percentage of the **C₁R_RT_CS_T** group, than of the **C₁R_RT_SS_{TL}** group (Tables 10.6 - 10.9, p.370-373), although the latter group was more populated (8 vs. 23 subjects).

Moreover, according to the wearer trial fit assessments, findings from both groups' data analysis demonstrated a general tendency of the dress toiles to provide a *satisfactory fit* for a larger percentage of the **C₁R_RT_CS_T** group, than of the **C₁R_RT_SS_{TL}** group (Table 10.14) - a fact that agreed with the findings using the '*Aggregate Loss of Fit*' formula (Tables 10.19 & 10.20, p.397 – Appendix E).

Overall, the average rating of the '**C₁R_RT_SS_{TL}** dress' fit, was found the same (moderate), although it was derived from different numerical values for each method of fit assessment (Table 10.19, p.397), whereas the average rating of the '**C₁R_RT_CS_T** dress' fit, was found the same (satisfactory), derived from similar numerical values for each method of fit assessment (Table 10.20, p.397).

To conclude, according to both the '*aggregate loss of fit*' findings and the '*wearer trial*' fit evaluations - despite the fact that the two measures for evaluating the dress fit, for both the **C₁R_RT_SS_{TL}** and the **C₁R_RT_CS_T** group, were assessed quite differently - **the average numeric ratings of the dress fit, for both groups - tried on different numbers of participants for each group - were found the same whether they were calculated using the '*aggregate loss of fit*' formula, or they were visually assessed after the wearer trials.**

Chapter 11

Contribution to Knowledge, Limitations, Potential Value, Discussion, Research Conclusions and Suggestions for future research

11.1. Contribution to knowledge based on accomplishment of research aims and objectives

Findings from the survey conducted for this research indicated that on a physical level, living with scoliosis can be a very complex process, whereas on a psychological level, it can become an even greater struggle. It was really interesting to find that 72% of the girls interviewed ($n=57$ out of 75: whole sample), described their scoliosis as a physical condition having no impact at all on their outward appearance, and 93.33% (nearly the whole sample) claimed that they had never needed to alter any retail garment due to their scoliosis, nevertheless, 41.33% ($n=31$ out of 75: whole sample) stated that they had often worn clothes made especially for them. Moreover, 85.33% ($n=64$ out of 75) didn't think that their scoliosis prevented them from following fashion trends as they wished, while 44.44% of the girls with severe spinal deformity ($n=4$ out of 9) claimed that they had been avoiding wearing close-fitting clothing, especially tops or coats.

Participants who would rather wear clothes designed conforming to their scoliosis were twice as many (60%) than those who would rather wear (customized or not) retail clothing (28%), and five times as many than those who wouldn't mind wearing any of the above (12%), while none of the girls with severe deformation ($n=0$ out of 9) would prefer to wear (customized or not) retail clothing. Moreover, 94.66% of the whole sample (and 100% - nine out of nine - of the girls with severe deformities: $n=9$) thought that there is a

great need for pattern design to comply with non-standard body sizes due to scoliosis. In general, the questionnaire indicated that certain adolescent girls with scoliosis – especially those with scoliosis from 55° onwards – indeed experience trouble finding clothes that fit their bodies and preferences, while implications of today's clothing fit for them are related to their feelings of self-esteem.

These findings pinpoint that there is, certainly, a need for developing a sizing system based on body asymmetry due to scoliosis, and if clothing that fits properly can help to enhance self-esteem of these adolescent girls, then great energy and support should be provided to make appropriate such clothing available.

The aim of this study was to classify 74 Greek females between 16-22 years of age, diagnosed with AIS, in new sizing systems that conform to their actual body size, taking into account the size and shape of their spinal deformity due to scoliosis, implementing a new approach to pattern design, with focus on user-oriented pattern design. Based on PCA and regression analysis, it was found that certain variables, concerning the left and right offset horizontal measurements and the corresponding vertical skew measurements associated with scoliosis, are strongly or partially correlated to each other, for the two most common *scoliotic* groups (Tables 7.22 & 7.25 and 7.23 & 7.26 - Appendix B). Moreover, frequency tables (Tables 7.34 & 7.35, Chapter 7.6.5:302-303) demonstrated that size distribution into five sizes was far more acceptable, using the two devised size charts, for this research (Tables 7.29 & 7.30, Chapter 7.6.3:297-298), than using the Greek Size Chart introduced by *the Greek Institute of Bodymetrics* that was based on the Greek National Survey 2006-2007 and represented the Greek female population between 20-24 years of age (Table 7.5, Chapter 7.5.1:263). The two proposed charts were different in terms of *height* and *hip*, *waist* and *bust circumferences* (key dimensions), concerning the two most populated scoliotic groups (Tables 7.29 & 7.30,

Chapter 7.6.3:297-298).

Hence, given that scoliosis is a 3D deformity, the assessment parameters for a scoliotic female body-shape identification shouldn't only be body size, but also body shape asymmetry due to scoliosis degrees.

In addition, it was found that in order to accommodate a right thoraco-lumbar scoliosis (51.35% of the whole sample: $n=38$ out of 74), in terms of apparel pattern design, the length of the bodice pattern (concerning the upper torso) would be shortened, while the width could remain the same (along the three different curve-sized Median Basic Bodice pattern blocks in size **M**), as the scoliotic degrees increase, owing to the physical deformation and its impact on the body shape (Figure 9.17, Chapter 9.5:352).

Hence, a larger sample (greater than $n=74$) providing more knowledge about body measurements and body shape variations, might render possible the development of an objective calculation pattern-grading method, based on numerical correlation parameters (Tables 7.22a, 7.25 & 7.27 and 7.23a, 7.26 & 7.28 - Appendix B), in order to identify the female scoliotic body shapes by using a few critical body dimensions (measurements 8a,b, 9a,b, 17a,b, 18c,d, 42a,b – Table 7.1, Chapter 7.3.2:228, and Measurement Table - Appendix B).

The sets of basic pattern blocks created for this research were addressed to girls with AIS, introducing 4 different basic garment styles (Bodice, Dress, Skirt and Trousers) and focused on body asymmetry due to scoliosis, conforming to the different left and right body halves. Such pattern profiles, based on *median* body measurements of adolescent girls' with scoliosis groups, identifying various types of scoliosis, were more tolerant of bodies with scoliosis, providing an improved garment fit in a bespoke, customised level that might have, in the long-term, positive implications on the mass-production of clothing, with the development of sizing systems based on body asymmetry.

Furthermore, the proposed basic pattern 'blocks' could be translated into various clothing styles in different fabric variations, introducing style-lines, darts, gathers or pleats in crucial areas of the upper torso, that could 'enhance' or 'mask' the scoliotic curvature, depending on the design.

The aim of this study was, therefore, accomplished, offering designers significant potential for creating innovative shapes in apparel pattern design.

The objectives of this research were to investigate the elements that determine the choice of clothes from the adolescent girl's with scoliosis point of view, to examine the key role pattern and fashion design can play in enhancing the quality of their lives and to study the ethical issues that emerge in designing well-fitting patterns, focusing on body asymmetry.

According to Isen, a product is made easier to use, simply by making it easier for people to find solutions to the problems *they* encounter (Isen, 2008:548-573). The aesthetic appearance of an apparel product (garment), thus, has a large bearing on its potential market share, and its ethical implications or consequences can have significant societal implications and *make* or *break* the moral reputation of the designer and manufacturer. In the case of *Clothing for Special Needs*, potential customers might have an idea of how they want the look of the particular design of a certain garment but to translate that into an actual garment requires certain skills, such as finding a balance between the body figure, the designed style and the necessary adaptations for accommodating any deformities. When designing individual patterns for individuals with severe deformities, the garments should have the appropriate style lines, in order to accommodate these deformities, which are crucial not only for the fit, but also for the hang and appearance of the garment. Achieving a good fit in one's clothes is one of the easiest and most effective ways to improve or enhance one's appearance (Chapter 5.1:126).

Findings from this study (Tables 10.19 & 10.20, p.397) pointed out that it is feasible to produce garments in a customised level that provide a good fit, derived from pattern profiles based on body measurements of teenage girls with scoliosis that conform to the girls' actual body size, 3D shape and type of scoliosis, after having identified the design elements and factors that will incorporate the '*ethical*' dimension in design, that refers to the '*intangible*' concerns – *trends, attitudes, values and lifestyle* – and the '*tangible*' concerns – the *body*, its *shape* and *sensory factors* (see Chapter 5.3:136).

Adolescent girls with scoliosis do not wish to be differentiated from their peers (normal controls), while they would appreciate if they could find fashionable clothing at affordable prices that would conform to their distinctive body shapes and figures (Chapter 3.5:59). The suggested pattern design system could be marketed focusing only on the two most populated scoliotic groups (the **C₁₋₂₋₃R_RT_SS_{TL}** group and the **C₁₋₂₋₃R_RT_CS_T** group), which cover 77% of the specific target market (Chapter 7.5.3:276), introducing new *garment sizes* that would conform, not only to the actual body size of girls with scoliosis, but also to their body shape according to their type and degrees of scoliosis (Tables 7.29 & 7.30, Chapter 7.6.3:297-298).

Hence, the objectives of this study were also accomplished, while the solution to the clothing dilemma for people with non-standard body figures, due to scoliosis, might lie in designing clothing in already accepted, basic, simple styles - which are, however, based on patterns conforming to body asymmetry - enhancing their notions of '*normality*', by introducing correctly fitting clothing in common shapes and cuts.

11.2. Research Limitations

This research, as most empirical research, had its limitations, either because of the methodology used, or by the very nature of the subject matter itself, or sometimes by a range of other unexpected factors. The fact it relied on self-selection, built an inherent

bias into the sample, as it inevitably attracted girls with scoliosis who wanted to share their experience. If this work would be further developed, it would be important to introduce group discussions and semi-structured interviews to target girls with scoliosis, who are not properly represented at this study, eg. girls who were reluctant to participate in the survey. A larger sample ($n > 75$) and more participant profiling would provide useful information on the profiles of girls aged 16-22 with scoliosis who are most attracted to custom-fit clothing and the areas of garment fit that are most problematic for them.

Furthermore, data gathering proved to be much more time-consuming than expected. The first five visits to G. Papanikolaou General Hospital failed, due to a two-month strike of the doctors affiliated with the Greek National Health System (NHS). This had as a result the cancellation of all appointments in the outpatient clinic, including those with scoliosis, which delayed the study, as only 2 subjects were measured, until that time, as opposed to 50 - my first goal in the three-month period October 2008 - January 2009. Moreover, the age of 'scoliotic cases' visiting the outpatient clinic, every Thursday, weren't always within the age group I was investigating. Although the initial sample, measured for this research, would consist of girls between 16-20 years of age, given that full physical maturity for the female skeleton has been reached by the seventeenth year of age (Coillard & Rivard, 2001:1140-1141), adding two extra years to the sample wouldn't have any serious impact on the research, while it would cover more 'scoliotic cases' in less time. Thus, I decided to raise the sample's maximum age limit up to 22 years of age, since girls with scoliosis, within the initial age group (16-20), were being very difficult to find.

After that, I experienced three or four more 'gaps', regarding my measurement-obtaining visits to the hospital, the maximum lasting three weeks without measuring any subject.

Overall, during this study, I realized that it was not easy to recruit girl volunteers for body measuring especially within tight time constraints: The girls had to enter the examination room, in order to get a diagnosis from the hospital's doctors and return to school as soon as possible, since the outpatient clinic took place in the morning time, when the patients normally would have been at school. Parents were also anticipating the time to leave the hospital, since they had to leave their jobs, in order to take their daughters to the outpatient clinic. This indicated that it was crucial to develop and apply a feasible recruitment strategy for such a body measuring survey: the essence of providing adequate fit is in the utilization of current and efficient anthropometric data from surveys.

Moreover, there were also certain limitations concerning the made-to-measure software system used for this research. The *PolypatternM2M* (made-to-measure) system could effectively alter the girth measurements, while, in certain cases, the system could not estimate and adjust automatically the shoulder-slope height onto the pattern design. In such cases, the shoulder slope height had to be adjusted manually.

Another limitation concerning the *Polypattern-M2M* software was the fact that pattern measurements for the larger body sizes, of all the scoliotic groups, incorporated the same amount of ease, as for the *base set* used for this research (**UK size 12** originated by W. Aldrich). The system was not able to produce patterns with extra ease for larger sizes, while this might have affected the final fitting results, since the *aggregate loss of fit* evaluations indicated an *unsatisfactory fit* for both subjects (12 & 42) representing size **XL** (the largest size) of the **C₁R_RT_SS_{TL}** group (see Table 10.1 – Appendix E). Patterns with extra ease for that specific size might provide a better fit for those subjects.

To conclude, the *sleeve crown height* had to be addressed manually, in certain cases, too, since the system could not extract an acceptable sleeve crown for the corresponding bodice (the sleeve crown height was too short for the corresponding armhole).

Nevertheless, having many advantages over traditional manual body measurement and pattern design procedures, such as being far less time-consuming, non-contact (using white light technology) and generating efficient anthropometric data for size charts and pattern generation, new technology using 3D body scanners, supported by CAD and automated custom-made patternmaking systems, could be ideal for future research, if these patternmaking systems were developed and improved.

11.3. Potential Value of the Research – Cost and Relevance to Industry

Computer-automated made-to-measure patternmaking methods enable the construction of garments custom-made to fit, in a very quick and accurate manner. These customized garments could be inserted into standard production lines as ‘*additional sizes*’ and produced like every other garment of the same fashion style. Moreover, automated CAD driven alteration methods could also allow different garment styles to be customized repeatedly, without time-consuming preparative activities, since well-established companies in the apparel industry, with huge databases of garment styles, are able to apply mass-customization strategies with relatively little effort at low cost. The decrease in returns due to ill fit would balance the decrease in production numbers, while resulting in increase in prices and customer loyalty (Istook, 2002:76). Moreover, efficient sizing is useful for marketing, especially in creating niches, targeting customers and facilitating consumer satisfaction.

After having done in-depth research, I found that the selection of contemporary designs for children, amputees, or even larger body types, is very limited, unless one wants to buy a simple T-shirt. Clothing designed specifically for women with Scoliosis is one market that is clearly underserved, while it can be provided only in a bespoke level.

Apparently, basic pattern ‘blocks’, that would serve people with scoliosis in a rather *customised* level could benefit a gap in the market that has been overlooked so far. Hence, the potential value of this research, apart from designing clothing for women with scoliosis in a bespoke level, involves designing for clothing companies addressed to people with disabilities or non-standard body configurations, with positive implications, in the long-term, on the mass-market.

Since *adaptive clothing*¹³⁵ companies were this research’s priority target, the researcher investigated the potential value of this study, to that particular segment of the market by contacting twenty-one major retailers of adaptive clothing. These included ‘*Able To Wear*’, ‘*Buck & Buck Designs*’, ‘*Adaptations by Adrian*’, ‘*Adaptive Clothing Showroom*’, ‘*Comfort Clothing*’, ‘*Adaptawear*’, ‘*Creations by Tu-RIGHTS*’, ‘*Designed To Care*’, ‘*Professional Fit Clothing*’, ‘*Rolli Moden*’, ‘*Rollin’ Wear*’, ‘*Silvert’s*’, ‘*Sweet Lemonade*’, ‘*Wardrobe Wagon*’, ‘*WeberWear*’ and other companies that design clothing for the physically challenged.

After explaining her project, the researcher asked them whether they would be interested in a future collaboration, in terms of pattern design, that could address the needs of females with different body configurations, so that their clothing / fashion products could be used inclusively, by a wider population market, given that scoliosis accounts today for almost 4% of the population worldwide.

Nineteen out of twenty-one companies didn’t respond at all, whereas others, like ‘*Anitavee’s Adaptive Apparel*’, or ‘*Designed To Care*’ replied negatively, claiming that the time and energy required to create custom clothing for special needs had not been worth it, from a business financial standpoint. In addition, certain companies, like ‘*Able To*

¹³⁵ Adaptive clothing: is ready-to-wear clothing, which is specifically constructed for use by the disabled (Definition in: Chase, R.W. & Quinn, M.D. 2003. *Design without limits: Designing and sewing for special needs*. New York: Fairchild Publications, Inc. P.2).

Wear', had been focusing only on wheelchair clothing, designing clothes to be worn while sitting - as distinct from clothing for people who have specific upper-body clothing requirements, as do people with scoliosis – and, thus, were unable to work with the researcher in terms of pattern design.

Nevertheless, certain companies, like '*Rollin' Wear*', '*Adaptive Clothing Showroom*' and '*Sweet Lemonade*', showed a great interest in a future collaboration, since they had been working with individuals with Scoliosis, already offering clothing in a bespoke level. Furthermore, '*Sweet Lemonade*' found the prospect of addressing the specific market, in a customised level, very exciting, suggesting a future collaboration with the researcher on a custom-pattern design basis.

Designers from different parts of the world, whose designs aim at their customers' comfort and good fit, producing clothing based on this concept, such as *Shelley Fox* (U.K.), *Izzy Camilleri* (Canada) and *Janska* (U.S.A) were also approached.

Janska hasn't responded to date, while *Shelley Fox* was based, at the time, in New York, and although she seemed interested, she had been finding it difficult to take on extra collaborations because of her work commitments.

Izzy Camilleri (Canada) showed a more positive attitude towards the researcher's project, as she had worked with people with Scoliosis in the past, understanding the challenges, regarding clothing and the issue of body asymmetry, while she suggested that a website introducing and selling online patterns for girls with scoliosis would promote this 'targeted' clothing line, as an excellent start.

Hence, it was concluded that the best way to try selling basic pattern 'blocks' for adolescents with scoliosis, in the market, would be to address each of the above companies, separately, suggesting that they could keep their individual style and just add some extra sizes that would conform to girls' bodies with scoliosis, based upon patterns

designed conforming to body asymmetry. The certain collection, based on each company's designs, while cut upon the basic pattern blocks proposed in this study, would maintain the certain dress-style of each company, accommodating specific scoliosis requirements.

Thus, potential collaborations would involve designing patterns, for any company that is interested - based on their own individual style— in different sizes for girls with scoliosis.

11.4. Discussion

Determining total and accurate anthropometry for clothing provision with traditional, manual methods can be intriguing regarding ethical considerations, such as the precise location of *body landmarks*, while how these are handled can be subjective due to the awkward positioning of certain measurement areas (i.e. crotch for inside leg measurement).

On the other hand, 3D body scanning technology is already in progress, having significant advantages in measuring the human body compared to traditional tape measurement methods, presenting possibilities of measuring a human body without physical contact and eliminating the likelihood of invalid, unreliable and subjective measurement procedures and vague judgements of posture. The extensive measurements and body models can provide a foundation for specified batch and individual pattern construction based on accurate body measurements, thereby eliminating observer error inherent in traditional methods, although 3D body scanning is, similarly, not without challenges related to the use of body landmarks (Simmons & Istook, 2003: 306-332). Certain scanners, such as the one used in this study, require subjects to wear undergarments for scanning, while there are image-based problems; where the body sways and is never really still and also the impact of breathing. This

study confirms challenges with applications determining subtle landmarks, such as the 7th cervical vertebra, which is usually found by feel at the back of the neck base, which could be obscured by subjects' hair. Shadows cast on areas of the subject's body also tended not record precise data due to light control (i.e. when wearing callipers on).

Notwithstanding, the [TC]² 3D Scanner Technology supports, today, revolution in healthcare measurement, taking its 3D Scanners and software — typically used to facilitate better fitting and/or custom-made apparel — into healthcare data collection, expecting to have significant benefits in identifying health risks, supporting a new patented process for measuring the shape of the human body in three dimensions, based on *Body Volume* rather than *Body Mass*. [TC]² 3D scanners and software have been used to provide the 3D human body shape images for development of *BVI* (Body Volume Index), while these images have been correlated with other medical information to provide risk indicators and a better reference model for individuals than *BMI* (Body Mass Index). The 3D scanners would provide detailed shape measurements, while suggesting that *BVI* long-term could be a more valuable healthcare risk predictor than *BMI*, which only measures the relationship between a person's height and weight (while *BVI*, again, is based on body shape in three dimensions to indicate health risk)¹³⁶.

In general, there are many advantages in using electronic-image data such as scanned data, as the body shape is described in precisely defined co-ordinates (x, y, z) and reproducible scanning allows data to be created in digital formats and features such as maximal and minimal measurements easy to numerically locate.

Furthermore, using computer-aided design (CAD) systems, it is now possible to manipulate body sizes and shapes of scanned data for 3D visualization (i.e.

¹³⁶ <http://www.tc2.com/pdf/kx16%20pressrelease.pdf> (Accessed 13th December 2013)

PolyPatternDesign, Lectra, Optitex, Gerber Technology, etc.), while integrated software is crucial to the process of linking the scan data to CAD patterns. Therefore, compatibility between systems needs to be ensured for the process of automatic generation and manipulation of garment patterns. Systems are usually web enabled and allow direct data transfer from the scanner over local networks or over the web into the existing CAD applications. Most body scanning systems now claim to be able to integrate scan data into current, available apparel CAD systems, allowing 2D pattern alteration and subsequently 3D garment generation.

Hence, apparel companies will benefit from several anthropometric studies that have scanned or are currently scanning representative groups of people from the population. The goal of these studies is to gain a better understanding of the current human sizes and shapes in order to develop sizing systems that fit most of the population. The validity of sizing provision, however, relies on the accurate and current measurement of relevant populations and the subsequent development of sizing charts for pattern and garment construction. Efficient sizing and fit is viewed as a marketing tool in creating niches in the market, targeting customers and preserving consumer satisfaction (Otieno, 2008:64), therefore, anthropometrics needs special attention, particularly the content, methods and underpinning analysis of data for the development of accurate garment sizing tables, which are paramount to the clothing industry.

It has been predicted that the dominant era of *standardisation* would come to an end (Toffler, 1970) and that *mass customisation* would overtake *standardisation* (Davis, 1987), as consumers' demand for choice, variety and unique products increase. The emergence of 3D Body scanning technologies and their integration with CAD systems have presented made-to-measure as a viable marketing tool (Devarajan & Istook, 2004:23), while with passing time, consumers would determine what, when, where and

how they want their products (Pine, 1993).

Today, consumers' demand for more options in shopping of '*personalised*' products is on the rise (Mouwitz *et al*, 2009). Body scanning is helping to shift the focus of apparel production *from mass production to mass customisation* with individualised sizing and design features and *made-to-measure* facility with competitive prices and faster turnaround times. Moreover, technology such as body scanning and customised pattern production provides the capability to understand and ultimately serve more targeted markets in women's wear, such as women with scoliosis.

This research found that participant responses to custom fit indicated that there is a consumer interest in *custom fit*, and that, using automated custom patternmaking software, it is possible to provide improved fit from standard RTW. Consumer education and marketing strategies would be needed to describe the sizing changes and guide customer selection, in order to fulfill the objective of creating a system that is understandable to and easy to use by the consumer. Good fit could become the emblem for progressive clothing companies, while the high-tech nature of the development would attract fashion innovators and young consumers, as the potential for better fit would interest women who have struggled to find clothing that fits (Loker, Ashdown & Schoenfelder, 2005:1-15).

Hence, a more dynamic way of evaluating body shape is required, while industry needs the ability to understand the range of body shapes that are present within a target market. This research project could be used as a cornerstone for providing retailers and apparel manufacturers a clearer perception of the diverse female body shapes and their relation to sizes, with the aim of specifying more accurately fit profiles for customers with divergent body configurations.

11.5. Research Conclusions

Changes in users' configuration and posture, caused by scoliosis, affect fit, usability and appearance of clothing, due to body asymmetry, while individuals with scoliosis and prominent disfigurement, usually, have balance and fit problems with standard garments, between the left and the right side, due to the fact that the projecting body part does not fit inside symmetrical conventional retail clothing. Hence, such a progressive, deforming condition is likely to have a serious physical and psychological impact upon the lives of female adolescents, since apparel, as the product of standard sizing, is reflected in female evaluation of self and body, i.e. body cathexis.

To date, as females who have the same bust, waist or hip circumference may have different figure shapes, the apparel industry faces challenges as RTW clothes are supposed to fit a variety of bodies. Current size charts and patternmaking models, especially for mass-produced garments, do not accurately reflect measurements across sizes or changes in body shape, as human bodies do not grow proportionally, having as a result current grading practices to contribute to fit problems. At the same time, economic and practical limitations in production and profitability have to be kept balanced, meaning that there are limited sizes available and that the industry has to prioritize some customer groups over others; the clothing market is not adapted for people with unusual body dimensions and/or different kinds of functional impairments, while accurate identification of body shapes (i.e. due to scoliosis) is a key issue to develop sizing standards for RTW clothing, or made-to-measure applications, based on non-standard body dimensions. Such sizing systems could result to fashionable clothing of high aesthetic values, conforming to scoliosis, which could give individuals with scoliosis back the value that was denied them, in terms of conformity and normality. Thus, there is an urgent need to verify existing patternmaking systems and methods, in

order to test their effectiveness in the quest for garments of the right size that fits well, feels comfortable and allows the body to move naturally.

This research project indicated the feasibility to classify 75 Greek females between 16-22 years of age, diagnosed with scoliosis, in new sizing systems that conform to their actual 3D body shape and size, as well as to the size of their scoliotic curve according to their type of scoliosis, having in mind that well-fitting clothing is important for women, enhancing their outward appearance and contributing to their feeling of confidence. A case study comparison on manual and scanning body measuring proved that the most appropriate method for measuring subjects' bodies, for this research, would be the manual measurement-obtaining method, using a tape measure, while it also proved that a slight change in posture (stance) of an individual's body has a considerable impact on their body measurements.

Thus, 75 adolescent girls were measured and 74 of them were classified in 180 scoliotic groups (*Subject 31* was excluded as outlier), according to their body size and their different types of scoliosis: 5 *sub-groups* according to their actual body size (XS, S, M, L, XL), 3 *main groups* according to the degrees of their scoliosis (Curve Size 1, 2, 3), 2 *sub-groups* according to the location of their scoliotic curve, in relation to sagittal plane (left / right), and 6 *sub-groups* according to the curve shape and the spinal region in which their major curve was located (Cervical, Cervico-thoracic, Thoracic, Thoraco-lumbar, Lumbar, Cervico-thoraco-lumbar). Later, subjects were classified into 90 scoliotic groups, after it was determined, based on medical data, that left and right types of scoliosis had the same clinical symptoms.

More specifically, according to these classifications, 51.35% of the sample ($n = 38$) belonged to the 'Right Thoraco-lumbar scoliosis' group ($C_{1-2-3}R_T S_{TL}$), while 12.16% ($n = 9$) belonged to the 'Right Thoracic scoliosis' group ($C_{1-2-3}R_T C_S$). Moreover, 58.10% (n

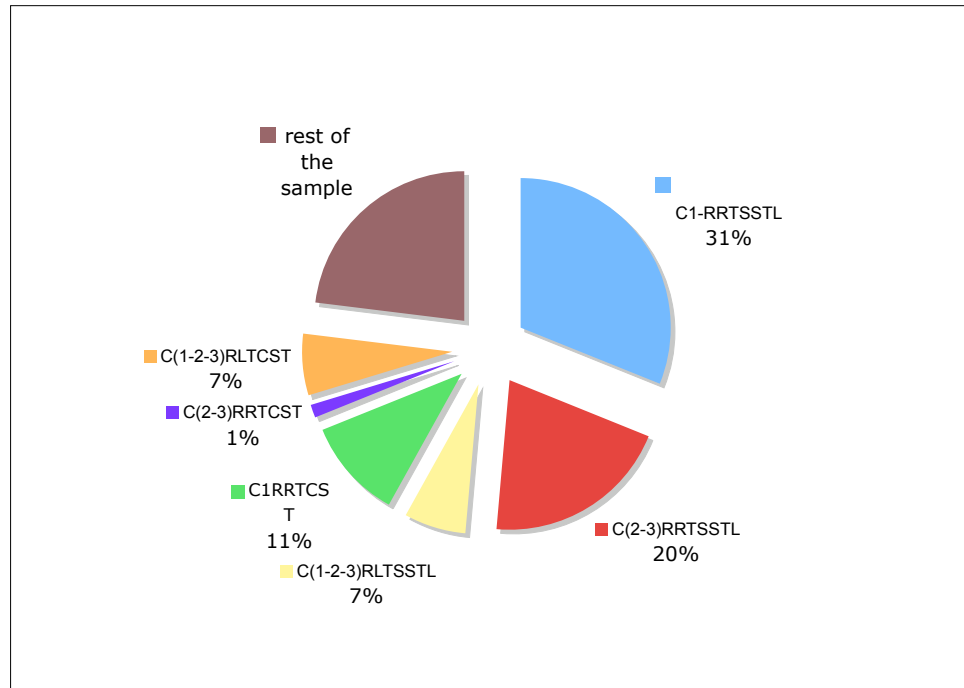
= 43) belonged to the **C₁₋₂₋₃R_{R-L}T_SS_{TL}** group (right & left thoraco-lumbar, including curve sizes 1,2,3), while 18.91% ($n = 14$) belonged to the **C₁₋₂₋₃R_{R-L}T_CS_T** group (right & left thoracic, including curve sizes 1,2,3) – both groups representing, together, 77.02% ($n = 57$) of the whole sample. The above findings agreed with general medical knowledge that 90% of thoracic curves are right convexity (curve to the right); 80% of thoraco-lumbar curves are also right convexity; and 70% of lumbar curves are left convexity. In addition, 67.56% ($n=50$) of the sample presented a mild spinal curvature ($10-34^\circ$), 20.27% ($n=15$) presented a moderate spinal curvature ($35-59^\circ$), and only 12.16% ($n=9$) presented a severe spinal curvature (from 60° onward) (Table 2.3, Chapter 2.1.1:25). In general, Table 10.21 (next page) depicts the two most common types of scoliosis, the **C₁R_RT_SS_{TL}** group (31.08%: $n=23$)¹³⁷ and the **C₁R_RT_CS_T** group (10.81%: $n=8$)¹³⁸, in relation to the whole sample ($n = 74$).

According to my findings (see Table 7.16, pp.274), the average Greek adolescent girl aged 16-22 years, diagnosed with some type of scoliosis of the spine, is 1.66m tall and weighs 58.82kg, her bust circumference is 91.25cm and her hip circumference 100.46cm, while these findings agreed with the findings of an earlier survey on 86 females, by the *Greek Institute of Bodymetrics*, during the time period 2006-2007, whereby the average Greek woman aged 20-24 years was found to be 1.63m tall, weighed 57kg, her bust circumference was 88cm and her hip circumference 98cm (Greek Institute of Bodymetrics, 2006-2007: 107-113).

¹³⁷ The **C₁R_RT_SS_{TL}** group is indicated in blue colour

¹³⁸ The **C₁R_RT_CS_T** group is indicated in green colour

Table 10.21: The **C₁R_RT_SS_{TL}** group and the **C₁R_RT_CS_T** group in relation to the whole sample



After obtaining subjects' body measurements and classifying them, according to the five *Greek generic sizes* (Table 7.12, Chapter 7.5.1:270), data were statistically analyzed and *Body Measurement Tables* (Tables 7.19abc & 7.20abc - Appendix B) and *Size Charts* (Tables 7.29 & 7.30, Chapter 7.6.3:297-298 and 7.27 & 7.28 - Appendix B) were developed, derived from *median body measurements* of women with scoliosis, classified in 180 different scoliotic groups according to their type of scoliosis.

The scoliotic curve size analysis and how it was affecting body shape was the starting stage of this study, in order to develop an improved patternmaking approach. After observing radiographs of both groups, it was evident that the body was shifted upwards to the right, with the right leg being longer than the left, so that the body could retain its balance (Figure 7.1, Chapter 7.4:246). Based on the correlation matrices of three different data sets, derived from the PCA (Tables 7.21a, 7.22a & 7.23a - Appendix B) and on linear regression analysis examining the relationship of horizontal offset and

vertical skew angle measurements with the Cobb angle (Tables 7.2ab, 7.3ab & 7.4ab, Chapter 7.4:246), it was found that there is no evidence of strong correlation between the degrees of a scoliotic curve – measured with the Cobb angle – and the angle of alignment at the bust, waist and hips of individuals with scoliosis, while certain variables, concerning the horizontal offset measurements and the corresponding vertical skew measurements associated with scoliosis, are strongly or partially correlated to each other, in both data sets, taken from the two most common *scoliotic group* samples (Tables 7.22 & 7.23 - Appendix B). Findings from PCA, according to factor loadings, also helped to define the key dimensions (Tables 7.25 & 7.26 - Appendix B) that provided the framework for the development of two size charts with the utilisation of *median values* and *standard deviations of 37 important variables*, in order to classify young women belonging to the two most populated scoliotic groups, thus, identifying the two most common types of scoliosis (Tables 7.27 & 7.28 - Appendix B). Further analysis showed that none of the two new size charts, developed for this study (Tables 7.29 & 7.30, Chapter 7.6.3:297-298), demonstrated the same intersize intervals for bust and hips (Table 7.31ab, Chapter 7.6.4:299), as many current sizing systems used today in industry - i.e. the BSI sizing system (Table 7.8, Chapter 7.5.1:266). Moreover, the bust-to-hip *drop values* of the two charts demonstrated a totally different patterning across the five sizes, the **C₁R_RT_SS_{TL}** chart *drop values* being the highest, having a steeper ascending tendency towards the larger sizes than the bust-to-hip *drop values* of the **C₁R_RT_CS_T** chart (Table 7.32, Chapter 7.6.4:300). Overall, using frequency tables (Tables 7.34 & 7.35, Chapter 7.6.5:302-303), it was found that size distribution into five sizes, in relation to *height* and *hip*, *waist* and *bust circumferences* (key dimensions), was far more acceptable, using the two devised size charts for the **C₁R_RT_SS_{TL}** and the **C₁R_RT_CS_T** groups (Tables 7.29 & 7.30, Chapter 7.6.3:297-298). The above findings, based on

anthropometric data, point towards the need for developing different size charts for different types of scoliosis.

Hence, the two devised size charts were further used for basic pattern block development, whereby four different garment styles of *Close-fitting Basic Pattern Blocks* were produced, owing to the fact that such blocks, having the minimum amount of ease required, would better indicate the areas of a garment that are mostly affected by body asymmetry due to scoliosis of the spine. Therefore, the set of basic pattern blocks used for women's garments, in this research, were: the basic close-fitting bodice, the basic close-fitting one-piece dress, the one-piece narrow sleeve, the tailored skirt and the basic trouser block, all originated from Winifred Aldrich's basic blocks (Figures 8.1-8.8, Chapter 8.2:311). Numbered *cardinal points (vertices)* were utilized to describe the outline of each pattern block (Figures 8.9-8.13, Chapter 8.3:318), in order to facilitate the pattern drafting procedure and to demonstrate how the patterns were developed, following specific *grade rules*, developed in the *PolypatternM2M* software, for each *vertex* of each pattern piece, of the four basic pattern styles (Tables 8.4-8.8 – Appendix C). Grade rules were based on mathematical formulas, while the variation of body curvature due to scoliosis, was addressed by creating a dart on the right-back side of the bodice and the dress pattern blocks. Cardinal point numbers were utilized to identify the location of a required action by the automated custom pattern design system (*PolyPatternM2M*), telling the system how to alter a pattern – how to increase or decrease in size, according to the grade rules created and applied to the pattern pieces – enabling, thus, other researchers to replicate the process and be able to build on it, in order to conduct further research. In using this software, a larger number of patterns over four garment styles for 57 subjects (22 out of 180 groups: 77% of the whole sample) was

generated and tested, when it would have been very time-consuming and nearly impossible to develop each pattern block, individually, if they were designed manually. Pattern development for asymmetric bodies due to scoliosis, derived from each scoliotic group's median measurements using summary statistics, was established by six experimental studies. After conducting these studies, it was found that the grading pattern between sizes **S**, **M** and **L** for the '*basic bodice block*', derived from *median* body measurements for the **C₃R_RT_SS_{TL}** group (Figure 9.10, Chapter 9.3:346), does not follow conventional grading rules of increment, from smaller to larger sizes – supposed to be the same for right and left side of the body – a fact that supports the findings of an earlier study by Bye *et al*, which indicated that in order to achieve optimum grading within a size range, grading practices should include measurement and shape variations. Overall, it was found that in order to accommodate a right thoraco-lumbar scoliosis, in terms of apparel pattern design, the length of the bodice pattern (concerning the upper torso) should be shortened, while the width could remain almost the same (along the three different curve-sized Median Basic Bodice pattern blocks in size M), as the scoliotic degrees increase, owing to the physical deformation and its impact on the body shape (Figure 9.17, Chapter 9.5:352). Hence, it would be possible to develop an objective calculation pattern-grading method, based in '*drop sizes*', focusing on numerical parameters and mathematical formulas. Finally, it was established that the 180 scoliotic groups can be reduced to half (90 groups), in terms of pattern design as well, owing to the fact that the pattern blocks for the left scoliotic groups can be reflected vertically, resulting in pattern blocks for the right scoliotic groups, and vice versa (Figure 9.20, Chapter 9.6:360).

The objective of the proposed sizing system was to group participants based on their body measurements, according to their actual body size and shape, along with the degrees and type of their scoliotic curvature, and then compare those groupings to the

assigned garment worn, during a wearer trial. The two-dimensional *extra* measurements (54a, 54b, 54c and 54d), used to define the location of the scoliotic curve, proved to be essential in improving existing RTW sizing systems, by enabling more intelligent groupings of the target market of girls with scoliosis, without increasing the number of sizes.

The produced patterns were, firstly, evaluated based on the '*aggregate loss of fit*' and then, made up in calico toiles for the two most populated scoliotic groups (representing the two most common types of scoliosis), so they could be tested in a wearer trial. The patterns for the wearer trial were evaluated, based on the researcher's subjective evaluation and on participants' comments regarding the toiles' fit.

Overall, for more reliable results, fit ratings from the garment trial were then compared to fit ratings from the '*aggregate loss of fit*', whereby it was found that the toiles constructed, based on pattern 'blocks' derived from the proposed size charts, could provide a *moderate* to *satisfactory* fit (average rating for both groups: 3 and 4) for the subjects assigned to those specific groups, according to the classification system proposed in this study. Thus, a larger sample providing more knowledge about body measurements and shape variations may lead to redefined size groupings, apart from the scoliotic groupings, as methods of incorporating body shape into grading practice so as to optimize apparel fit.

In conclusion, it is feasible to produce garments in a customised level, derived from pattern profiles based on body measurements of teenage girls with scoliosis, classified in the same size group, that conform to the girls' actual body size, 3D shape and type of scoliosis. The measurement and pattern design methods, presented in this study, could be further improved or adapted, by increasing the scoliotic sample being measured [total sample: ($n=74$), $C_{1-2-3}R_R T_S S_{TL}$ group sample: ($n=23$), $C_{1-2-3}R_R T_C S_T$ group sample: (n

=8)], in order to obtain a larger data amount, contributing, thus, to the constant development of specialisation in the pattern design field.

11.6. Suggestions for future research

Developing a new sizing system that is based on the latest anthropometric studies and corresponds to the given body dimensions, providing possibilities for larger variety in size selections for people with diverse body figures, entails challenges on several levels. A main challenge is, of course, to organize information on sizing systems, in a way that does not reinforce the stigmatizing aspects of the sizes that do not fit the prevailing beauty ideals. It is a paradox that those who really need good clothing to make their bodies '*socially acceptable*' are those who have the least choice and the greatest difficulty in finding clothing that fits (Laitala, Klepp & Hauge, 2011:37-38). Failing to find clothes that fit supports the further stigmatization and materialization of the judgmental gaze cast upon people whose bodies do not conform to beauty ideals.

In mathematical modelling for body shape distribution (i.e. hourglass, apple or pear) geometric groupings (i.e. triangle, rectangle or oval) are based on bust, waist and hip measurements, which are the *industry standard* principle *key dimensions* (as confirmed by PCA, Chapter 7.6.2:291). Although we have qualitative research into body shape, it has not yet been taken up by the industry and included as part of standard sizing systems. Hence, the concept of introducing medical terms for shape identification is a good idea for future research but it has to be built on a solid foundation.

Besides, the growth trend in the global functional garment market has been well-established, over the past decade, and is expected to grow further in the coming years. Behind this demand for more *functional garments* lies the ascending focus on *health* and

safety, as well as the realization of the fact that innovative pattern design of garments cannot only provide *protection* and *comfort* but can actually assist in enhancing the *performance* and *productivity*.

In addition, another noticeable trend in innovative pattern and garment design is the union of *ergonomics* and *fashion*, where the demand has been increasing for garments, which apart from having the required functional qualities, are also aesthetically pleasing and provide the wearer a stylish and fashionable look. This demand for '*function for fashion*' has encouraged apparel manufacturers to introduce innovative and conceptual design systems and methods in pattern and clothing design, as well as in fit and end use of fabrics and technologies that benefit higher performance and aesthetic qualities.

Over the past few years, a number of contactless 3-D body scanner / measurement devices and techniques have been developed (Inspeck, Cyberware, TC2, Minolta Vivid, Vitus 3D). The range of application areas is rapidly expanding for 3D body modelling and measurements, including animation, anthropometry, computer games, ergonomics, made-to-measure clothing, medical, movies, and virtual reality. Current and potential medical applications include brace design, cosmetic surgery, posture evaluation, body weight control, and scoliosis monitoring (Pazos *et al*, 2007:1882-1891).

The lack, however, of reliable techniques to follow up scoliotic deformity from the external asymmetry of the trunk leads to a general use of X-rays and indices of spinal deformity. Young adolescents with idiopathic scoliosis need intensive follow-ups for many years and, consequently, they are repeatedly exposed to ionising radiation, which is hazardous to their long-term health. Furthermore, treatments attempt to improve both spinal and surface deformities. A study by Pazos *et al*. (2005) identified the need to develop a commercial, optical 3D digitising system for the 3D reconstruction of the entire trunk for clinical assessment of external asymmetry. The resulting surface is a textured,

high-density polygonal mesh, while the accuracy assessment was based on repeated reconstructions of a manikin with markers fixed on it (Pazos *et al*, 2005:11-15). Contrary to the assessment of scoliotic deformities from X-ray images, where the Cobb angle is the gold standard, there is no consensus on a set of indices that can be used to assess these deformities from the trunk surface, quantifying the apparent asymmetry associated with the spinal deformity (Pazos *et al*, 2007:1882-1891) – a fact that points toward the quest for new ways of looking at the Cobb angle and spinal regions, from a 3D perspective, focusing also on the rotation of the vertebrae, by utilising 3D body scanning technology.

Hence, classifying asymmetrical body shapes due to scoliosis is a necessity both for RTW and M2M approaches, since the general incidence of AIS has been reported to range from 2% to 4%, worldwide (Weinstein, 1989:115-128). Thus, the *Body Shape Assessment Scale* (BSAS) – a female shape analysis tool created by Connell *et al*. (2006:92), based on Biederman's and Mossiman's theories and Douty's creation of five-step body build and posture scales, could be revised, due to the fact that when creating the scales and programming the software, left / right asymmetry was not previously considered, while experts evaluated body scan images based only on the right side, presuming that the left side would be symmetrical.

A considerable amount of detailed sets of body measurements and their well-fitted custom patterns were obtained from this study, providing permanent records for convenient analysis of body shape difference and garment fit for females aged 16-22 years with scoliosis. Data inserted in *MS Excel* worksheets to facilitate statistical analysis, could be further augmented, while used as the basis for quantifying the variations between the pattern and the body with scoliosis. Although the 75 subjects

measured provide a rather adequate sample to base a pattern design method, in order to create a set of basic pattern 'blocks' derived from their *median* body measurements, for more in-depth and accurate findings, it would be more legitimate to have a larger sample ($n > 75$) – of about 350 adolescent females with different types of AIS – for a future survey. While this is one of the researcher's goals, for a future Post-Doctorate Study, future researchers should be encouraged to continue to build on this research findings (classification of more subjects in each of the 180 scoliotic groups), trying to augment the specific scoliotic sample.

Further analysis is also required with the increased set of numbers, in other countries apart from Greece. The results could be then compared with the national size surveys, with more localized sample data sets. Sorting the groups according to age, nationality, religion or race differences may help to get more accurate classification parameters or more definite borders for each cluster. Further studies are also needed on methods of creating a body size chart that reflects the body shapes of females with scoliosis, developing correctly graded patterns conforming to body asymmetry.

The two size charts proposed in this study (Tables 7.29 & 7.30, Chapter 7.6.3:297-298 and Tables 7.27 & 7.28 - Appendix B) require numerous participants as representative members of girls' with scoliosis target market to evaluate fit, involving about 50 participants for each expected size category, that is, at least 9000 participants for all 180 groups.

Overall, in this research project, the process of how an *individual garment* is made-up to fit an adolescent girl with scoliosis of the spine, using automated custom pattern design software has been explored, while main attention has been drawn on the *individual pattern* and, in relation to that, each subject's body classification.

It might be worth-studying whether the same procedure of designing individual patterns could be applied for different kinds of impairments, disabilities or disfigurements. In any case, the best approach would be to sew test garments during the making-up process.

The emphasis of my research up till now has been on setting an agenda from the perspective of girls with scoliosis, how they feel about conventional retail clothing, what are the types of clothes they prefer to wear, or what are the alternatives conforming to their scoliosis. In the future, it would be useful to gather more information, in detail, about the characteristics of clothes (fabrics, colours, cuts, shapes, etc.), accommodating better individuals' needs and preferences.

Nevertheless, the material elicited from this research and the sets of basic pattern 'blocks' for clothing females with scoliosis, provides a useful starting point for highlighting a neglected area of experiences, concerning the question of how would a female scoliotic body shape classification system look like, for the use of RTW (ready-to-wear) or M2M (made-to-measure) clothing.

To conclude, this study does not incorporate any comparative work with girls that don't have scoliosis or boys with scoliosis, while one could imagine that many of the issues raised are not unique to adolescent girls with scoliosis. However the central thrust of this research was to demonstrate the extent to which scoliosis can shape the lives of adolescent girls diagnosed with AIS, and to highlight the need to include them in pattern and fashion design, by introducing ergonomically designed asymmetric patterns in order to accommodate their bodies' asymmetry.

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